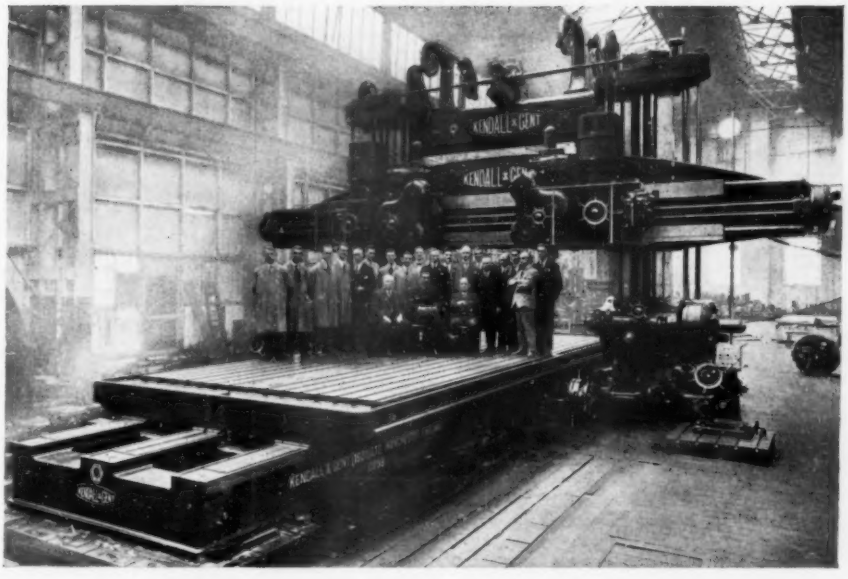
METALLURGIA

THE BRITISH JOURNAL OF METALS.

OCTOBER, 1932. VOL. VI., NO. 36.

A Heavy-Duty Plano-Milling Machine

Weighing over 200 tons, and operated electrically, a large plano-milling machine constructed by Messrs. Kendall and Gent, Manchester, to the order of a foreign government, embraces many interesting features. It will machine work 28 ft. long, 12 ft. wide by 8 ft. high, and is believed to be the largest of its type constructed in this country. The movements of its various parts are controlled by push buttons. The outstanding features of this machine are briefly discussed.



THE modern workshop manager no longer believes that the loss of time attendant upon resetting a piece of work requiring machining on more than one face to be inevitable, and often requires a machine which will enable heavy castings, such as large Diesel engine and similar parts, locomotive cylinders, etc., to be more nearly finished at one setting. The heavy-duty plano-milling machine illustrated is a case in point; with its four cutting heads, two of them capable of being set at an angle, a variety of machining operations can be carried out consecutively with a resultant saving in production time, and with that high degree of accuracy obtained not only by rigidity of construction, but by eliminating the possibility of error through incorrect resetting of the work. The machine is made by Messrs. Kendall and Gent (1920), Ltd., Manchester, and, as will be seen by the accompanying illustration, it is of exceptional size, being, we believe, the largest of its type so far constructed in Great Britain. The machine can handle work 28 ft. long by 12 ft. wide by 8 ft. high, but its flexibility, particularly in cases where simultaneous use of the multiple heads is concerned, makes it suitable for work which presents difficulties other than those of mere size.

An idea of the general construction will be obtained from the illustration. The bed is of box section, and, throughout its length of 53 ft. rests on the foundation. The columns, with a widespread base, also rest on the foundation. They are bolted to the sides of the bed and are connected at the top by a cross-stay of box section. The cross-slide is notable for its depth, and is mounted upon broad ways on the face of the columns, upon which ways the two side saddles also move. The side saddles have horizontal spindles, one of which is fixed, while the other can be swivelled in a vertical plane through an angle of 20° above and below the centre line. The saddles on the cross-slide, carrying the vertical spindles, are similarly arranged, one having a fixed axis, and the other swivelling in a plane parallel to the slide face through 20° on each side of the vertical axis. The table is 12 ft. 6 in. wide overall by 33 ft. long, and is made in four parts with longitudinal and transverse joints. It is unusually deep, and is provided with heavy ribs to prevent deflection under heavy loads, while the joints are rigidly made. The table slides on three ways on the bed, which is of close-grained cast iron. The ways are flanked on each side by a deep groove to catch surplus oil, which is drained from a sump at the ends. The sliding faces of the table are provided with spirally cut grooves to ensure effective lubrication.

The traversing motion is given to the table by two worms engaging with racks of semicircular cross-section. The end thrust is taken by heavy ball washers. The worms and racks are of iron, and were cast in special moulds by a process ensuring exceptionally close-grained castings of high tensile strength. The table was cast with the upper surface solid, the tee-slots being machined out afterwards. The worms are driven by a 20-h.p. reversible motor mounted on a gearbox, and transmitting motion to the first motion shaft through an enclosed Texrope drive. This shaft also carries a pulley, which drives, through a flat belt, the quick-power traverse of the table, and is prolonged in the other direction into the main gearbox. This has hardened steel gearing mounted on splined shafts and running in oil. The table feeds range from 1½ in. to 12 in. per min., and the quick-power traverse is 6 ft. per min. The saddles also derive their feed motion from the gearbox, which provides nine correctly graduated feeds for each spindle speed. All the power feeds and traverse motions may be operated

independently or simultaneously, by means of conveniently placed levers and push-button switches. These are duplicated on the two sides of the machine, so that the operator has full control from whichever side he happens to be on, a factor contributing to high output in a large machine of this character.

The side saddles are balanced and are provided with hand and variable self-acting reversible feed-motions vertically, together with rapid traverse for setting. The spindles are of heat-treated high-tensile steel, running in adjustable conical gunmetal bearings, the front bearings being carried in a steel sleeve which is provided with a fine adjustment for putting on the cut, by means of a worm-wheel, rack, and pinion. The housing is closed firmly on the sleeve by efficient locking bolts, thus rendering the sleeve practically solid with the saddle. The spindle noses have a recess for receiving the cutters or mandrels, the drive being provided by flats on the collar, while large face cutters are mounted direct on the flange on the spindle. The spindle speeds range from 6 r.p.m. to 24 r.p.m., and the spindles have an adjustment along the horizontal axis of 1 ft. 6 in. The feed-motions on the column ways range from $\frac{3}{4}$ in. to 6 in. per min., with a quick traverse of 2 ft. 3 in. per min. Both horizontal spindles are driven by a 60-h.p. variable-speed motor situated at the left-hand side of the machine, and having a 4-to-1 speed ratio. Power is transmitted by a Texrope drive through a gearbox.

Both vertical spindles have independent drives, each being fitted with a 30-h.p. motor having a speed variation of 4 to 1. The motors are connected to the spindles by direct gear-wheel drives. The spindle speeds are the same as those of the horizontal saddles, but the spindle adjustment and the feed rates differ, being in this case 1 ft. and $1\frac{1}{2}$ in. to 12 in. per min. respectively. The rapid traverse of the vertical saddles along the cross-slide is 3 ft. per min. The motors for the saddles being movable, flexible cables are provided. These are carried over aluminium pulleys, mounted on brackets on the top of the column cross-stay. This stay also carries a reversible motor for traversing the cross-slide on the columns, the speed of this operation being 1 ft. 6 in. per min. To obviate any possibility of the cross-slide becoming out of truth, due to excessive wear on the elevating screws, a compensating clutch is provided on the horizontal shaft transmitting the drive. The cross-slide is partly balanced to effect easy movement, and is amply deep at the centre to prevent any deflection when both saddles are together at this point. The hand and variable self-acting feed-motions of the saddles, as well as the quick-power traverse, may be operated from the platform attached to each saddle.

The electrical equipment of the machine was supplied by Messrs. Metropolitan Vickers Electrical Company, Ltd. Trafford Park, Manchester. The control panels are of the contactor type, with special interlocking devices governing the panel control for the feed motor. In the event of any spindle stopping, the feed motor is automatically cut off, thus preventing any damage to the milling cutters. It is, further, impossible to operate the feed-motions without first starting the spindle required for the particular operation concerned. When, however, the table and saddles are to be moved for setting purposes, a change-over switch is used. The push-button controls enable the operator to start, stop, inch, and reverse every motion of the machine from the normal operating position. The lubrication of the machine is thoroughly carried out. Wherever it was possible, splash lubrication has been adopted, and for other positions, "one-shot" lubrication on the Enot system has been fitted.

The remarkable outputs to be obtained on this machine are mainly due to the universal character of the general motions and other features, particularly when in operation on work which calls for the simultaneous use of the multiple heads. Although of unusual dimensions, it will be readily appreciated that similar designs of machines, but of smaller capacities, can be supplied to suit a customer's particular requirements.

History of Anchors.

In his presidential address to the Staffordshire Iron and Steel Institute, Mr. A. E. Osborn chose the subject of anchors. The story of the anchor, he said, was almost, but not quite, as old as the story of ships. The first primitive form of anchor came into being in the shape of heavy stones or bags of stones which were thrown overboard, attached by ropes to the ship, mention of which is made in the Odyssey, Book XV., line 498. It would perhaps be more correct to consider these mooring stones as the prototypes of "killicks." The latter are stone, or stone and wood, deviced for mooring small boats, and are used even at the present day by fishermen in various parts of the world. The first stage of these articles was merely a rope tied round a stone, whilst the fifth stage could be regarded as a primitive grapnel, and was a four-armed killick, which had begun to take on true anchor form.

A completely new chapter had been added to the knowledge about anchors as a result of the excavations by the Italian Government in Lake Nemi with reference to the two galleys of the Emperor Caligula. The first galley was exposed in 1929, and about 100 yds. to the starboard of the boat there was discovered an iron anchor, encased in a wooden sheathing. After this sheathing had been removed it was found that except for details of the flukes and the length of the shank in proportion to the chord of the arms, this anchor differed little from the early type of Rodger's anchor, which had a detachable iron stock and was patented in 1846.

Conditions altered little from 1815 until the end of the nineteenth century, any development that took place being rather of design than of size or weight. There was a gradual evolution from the old type of anchor with a fixed head and wooden stock to the modern stockless anchor with a movable head. The first stockless anchor patented was Hawkins' in 1821; but before the stockless anchor found favour the Rodgers, Trotman, and Porter types of anchors were in use.

In 1888 the modern type of stockless anchor was patented, and has been subsequently known throughout the world as Hall's type of anchor. The essentially new principle of this anchor was that the head swivelled through a limited angle of swing on a trunnion passing through the shank. The entire head of the anchor from fluke to fluke was in one bow-shaped piece, and both flukes entered the ground simultaneously. Hall's anchor was a success, and still remains the most popular type used by the mercantile marine.

The Institution of Automobile Engineers.

The opening meeting of the new session of the Institution of Automobile Engineers took place on October 4 at the Royal Society of Arts, Adelphi, London, when Major C. G. Nevatt, chief engineer of the British Tramways and Carriage Co., Ltd., was inducted into the chair as president of the Institution for the ensuing session, when he delivered his presidential address, choosing as his subject "Legislation and the Automobile Engineer." At this meeting the various awards for the past session were presented, among these being the first Simms Gold Medal of the Institution, which was awarded to Mr. A. J. Rowledge, of Rolls-Royce, Ltd., for his work on design and research of outstanding merit, in connection with high-speed aircraft.

Royal Aeronautical Society's Awards.

The following awards have been made at a Council meeting of the Royal Aeronautical Society:—

Silver Medal.—Señor Juan de la Cierva, F.R.A.E.S., for his work in connection with the development of the autogiro.

Simms Gold Medal.—Mr. P. Salmon, M.I.Mech.E., M.I.A.E., for his paper and work on catapults.

Wakefield Gold Medal.—Mr. D. H. Williams, B.Sc., A.F.R.A.E.S., and Mr. A. R. Collar, B.A., B.Sc., for their joint paper on "The Motion of an Airship under Certain Conditions."

Pilcher Memorial Prize.—Mr. F. W. Dowsett, Stud., R.A.E.S.I., for his paper on "The Design of Aeroplane Controls and Control System."

The Influence of Metallurgical Developments on Furnace Practice

The development of the mechanical furnace is largely dependent on the application of materials capable of combining refractory, structural, and workable properties to build a furnace to operate at the temperature desired. Materials available are discussed.

An important feature of modern technical progress in furnace design is the development of the mechanical furnace, which has economic and operative advantages both in reduction of costs of operation and economy of fuel. Its progress is largely bound up in the application of materials capable of combining the necessary refractory, structural, and workable properties to build a machine to operate at the temperature ruling. The subject is discussed by R. J. Sarjant, M.Sc., in a paper, presented at a recent meeting of the Ceramic Society held in London, in which he dealt with some factors affecting furnace design.

The properties demanded in these materials comprise stability in resistance to the sealing action of the furnace atmosphere, fluxes, fumes, and other corroding media, physical stability, and strength at high temperatures, and such workability as may enable fabrication to be carried out in any of the forms which the technique of the furnace construction requires. Suitable materials are broadly divided into three classes, according to the range of temperature most suitable for their uses.

Class I.—Alloy steels utilised for a low temperature range up to 600° C. These are chiefly alloys of chromium, which is present in various amounts, together with small additions of nickel and molybdenum. These steels are fabricated in the forms common to the better known alloy steels, and have been developed primarily to meet the requirements of steam plant employing enhanced degrees of superheat. The special properties are an increased resistance to "creep" at the intermediate temperatures of high-steam superheat, and an absence of any embrittlement occurring with lapse of time under the conditions of service—for example, in bolts and superheater tubes.

Class II.—Alloy steels, utilised in a range with a limiting temperature of 950° C. for general furnace uses, containing 18 to 25% of chromium, and 7 to 12% of nickel, with additions of silicon and tungsten.

Class III.—Materials utilised for a high temperature range, to 1,100° C., in which either high chromium irons containing 0·5 to 2% of carbon and 25 to 30% of chromium, or high nickel chromium steels containing between 15 and 30% of chromium and 12 to 80% of nickel are used.

A dominant property of these alloys is strength at high temperatures, and the question of stability under repeated heating and cooling is frequently of critical significance in their successful application, while their resistance to scaling is relatively of a high order. A further outstanding feature of these alloys is that they can be produced as castings, forgings, rolled bar and sections, sheet, wire, and drawn tubes, thus meeting the requirements of modern practice in high-temperature engineering. Both castings and forgings are readily machinable, though the material is considerably tougher than ordinary structural steels, and machining is, in consequence, slower under the same conditions. These alloys also weld readily to themselves and to other steels by means of either the oxy-acetylene flame or the electric arc, when specially prepared electrodes and welding rods are employed.

Design and Workmanship.

In regard to the general question of the comparison of cast and malleable forms, the following general principles are noteworthy. In any furnace auxiliary subjected to the action of heat, apart from scale resistance and strength at high temperatures, design is of paramount importance. In hearth plates, muffles, dampers, containers for use in furnaces, indeed in any type of cast or rolled plate, the even distribution of temperature is a pertinent factor governing the life of the material. Better service is obtained from castings built up in sections. Greater stiffness at high temperatures may be obtained in the case of material which has only to be cast and not forged or rolled. In the cast form also the material is inherently more stable, and in some cases actually stronger at high temperatures. Such a condition presupposes soundness of casting. If there is, however, any danger of unsoundness in casting, a risk not eliminated with certainty in complicated forms, or designs devised without due attention to the conditions of casting, then the forged or rolled material may be preferable. This is particularly the case where there occurs in service exposure to repeated heating and cooling. With built-up containers, for instance, experience has indicated a preference for welded types. Annealing boxes of this form have given a life exceeding eighteen months at operating temperatures of 750°–1,100° C. with Class II. alloys. A further advantage of containers built from welded sheet is that thinner walls may be used, thereby reducing fuel consumption, a saving of as much as 20% being reported. In carburising boxes, there is a danger of cracking with the cast forms. There is also attack by the carbonising medium. In such cases alloys of high nickel content, 15% chromium and 35–60% nickel, and alloys containing 25–28% chromium and 10–18% nickel, have given good service, a life of from 3,000 to 5,000 hours being obtained.

Furnace components such as skid rails, supporting racks, chutes, rollers, and components of conveyors, which have to be subjected not only to the full furnace temperature, but also to considerable fluctuation of temperature, must be constructed with freedom to expand and safeguards in design against warping and distortion. The forces due to thermal expansion are very great, but are suitably countered by correct attention to design. The successful combination of the variable factors is a matter of extended experience of fabrication of these alloys, and this practice must always retain in some respects the attributes of an art.

Firing of Ceramics.

In the firing of kilns for the manufacture of ceramic products heat-resisting steels have been applied for kiln furniture, in the construction of batts, supports, and cranks for the packing of ware in the kilns. A special requirement is that the small amount of scale produced must be firmly adherent to the metal, and not projected on to the ware, for in that case spoiled ware is the result. A further feature of the utility of heat-resisting steels is that a lighter construction is made practicable, having the treble advantages of saving fuel in repeated heating and cooling, reducing the risk of breakage of ware in handling, as well as the actual lifting to be done in charging and discharging the kiln. The malleability of various types widens the scope of design in attaining these ends. In the case of using the alloy as a reinforcement for refractory coverings, breakage of the refractory in service does not result in the ware falling out of place, since the reinforcement retains its shape. In the hard firing of

decorative ware in enamelling kilns, the use of a Class III. type of alloy has become established practice on an extended scale. Tie-bars, bolts, and nuts for muffle kilns, sand seal plates, pans, trays, and fan blades are further applications.

In glost firing the presence of lead fumes, which have a strong corrosive effect at the high temperatures employed, have proved a disability, the production of lead chromate occurring. A similar experience has been encountered in a special instance in the cement industry, in which the presence of potassium chromate was detected in the case of a Class II. alloy, where blistering had occurred in a liner plate of a cooler chute. Fluxing with alkali in the calcined material had occurred at temperatures of 1,000° C.

Vitreous Enamelling.

In the vitreous enamelling industry the conditions are somewhat similar, though in some respects still more exacting. In pottery kilns care is taken to eliminate the presence of sulphurous gases. These may be present in the atmosphere of vitreous enamelling furnaces. There is generally repeated heating and cooling in the case of supports and perrets. The structure must be light, no embrittlement must occur with extended service, and there must be no decrepitation of scale. Further, the glaze used is of a strongly corrosive nature. The ingredients are oxides of tin, nickel, molybdenum, iron, manganese, etc., and such active fluxes as borax, fluorspar, cryolite, and sodium nitrate.

For ware fired at 800°–850° C. the austenitic nickel-chromium-tungsten type of material, Class II, is satisfactory. For higher temperatures the more highly alloyed steels of Class III are necessary—thus, 60–65% nickel and 15–20% chromium, and 35–40% nickel and 15% chromium. In America there is some partiality for alloys containing 17 to 22% of chromium, 30 to 39% of nickel, with small additions of manganese and silicon.[1]

Castings prove more economical than built-up constructions, although somewhat heavier. Such supporting grids have been found to be economical, although their cost may be forty times greater than that of mild steel previously used.[2]

Recuperators.

Some considerable experience has now been obtained in the use of heat-resisting steels for recuperators. Definite conclusions have accordingly been obtained regarding the types of design most suitable and the life attainable in specific types of plant. Drawn tubes have been applied usefully, but in general the most economical form of recuperator is constructed of welded cast tubes. Variety of fashion is thereby obtainable, whereby special provision of webs and flanges to increase heat transmission are practicable. High velocities can be carried, and overall coefficients of heat transmission are practicable. High velocities can be carried and overall coefficients of heat transfer as high as 25·8 B.th.u. per sq. ft. per hour per ° F. have been obtained.[3] In the use of special materials in which the question of cost of material may become an important item in the economic balance-sheet, it is essential to obtain as high a rate of utilisation of surface of heat exchange as practicable. Generally, in the heat balance of a flame furnace the loss of sensible heat in the waste gases is the principal item. Losses of as much as 50–60% of the potential heat of the fuel are encountered, and rarely, with the use of normal chimney draught, does this loss fall below 20%. Heat recuperation is frequently a practicable form of heat economy. The refractory recuperator has the disadvantage of being fragile, of high heat capacity, slow in becoming effective in the heating cycle, and wasteful of building space. Further, the use of the chimney is generally required to be retained as the means of assisting the draughting of the furnace, so that there is a limit to the heat which it is desired to remove from the waste gases. The following is proposed as the standpoint from which the problem should be viewed. Consideration should be given to the relationship between the degree of preheat and its potential advantage in the general economy of the furnace operation. That is to say, the highest temperature of preheat is not necessarily the most economical, having regard to the construction of the recuperator and the loss of draught, but partial recuperation may be readily practicable and of considerable advantage.

Metallic recuperators have been applied successfully to the heating of primary air in conjunction with coal-fired forge furnaces operating at 1,150° C. A life of five years in the tubes has been obtained. A moderate preheat on the primary air (300°–500° C.) is as effective in heat recuperation as a high degree of preheat in secondary air (800°–900° C.) using the type of built-in gas producer, known as the semi-gas furnace. Incidentally, it may be mentioned that by means of a special provision for automatically controlling the air supply, it has been possible to operate the furnaces without the production of undesirable quantities of smoke—a contribution towards the problem of smoke abatement.

1 "Effect of Temperature on the Properties of Metals." A.S.T.M. Symposium, 1931
2 W. Rohn, *Zeit. Ver. deut. Ing.* 42, 1,478, 1927.
3 "Industrial Heating by Solid, Liquid, and Gaseous Fuels." Sir Robert Hadfield and R. J. Sarjant, Paper K 9, Fuel Conference, W.P.C. (1928) 22.

Programme of Institute of Metals.

THE Institute of Metals has just issued a comprehensive programme of meetings to be held during the ensuing twelve months. The coming year promises to be a notable one in the history of the Institute in that it marks the twenty-fifth anniversary of its foundation. The twenty-fifth annual general meeting will be held on March 8—9 in London, whilst the silver jubilee autumn meeting—which will constitute the real anniversary gathering—will be held in September in a provincial centre. The remaining general meeting of the Institute will be held on the occasion of the twenty-third annual May lecture, to be given in London on May 10.

The programme includes particulars of over 40 lectures and addresses to be given before the local sections of the Institute, which are centred, respectively, in Birmingham, Glasgow, London, Newcastle-on-Tyne, Sheffield, and Swansea. These lectures are of an essentially practical character, being intended to appeal particularly to workers engaged in local industries. Thus, among the papers to be read before the Birmingham local section will be those on "Heat-treatment without a Detrimental Finish," and "Welding of Copper." The London local section is fortunate in having an address by the President of the Institute, Sir Henry Fowler, K.B.E., LL.D., D.Sc., on "Non-ferrous Metals and Alloys in Railway Engineering"; there will also be an open discussion on "Non-ferrous Metals in the Food Industry," this constituting a joint meeting with the food group of the Society of Chemical Industry. The programme of the Glasgow section includes a paper on "Modern Light Alloys, with particular reference to Corrosion." Similarly, before the North-east Coast local section, which is centred at Newcastle-on-Tyne, there will be given a paper on "Corrosion of Metals in Salt Solutions and Sea-water," this being a joint meeting with the Society of Chemical Industry. Sheffield members will hear with special interest a lecture by a vice-president of the Institute, Mr. W. R. Barclay, O.B.E., on "Nickel-silver Alloys for the Electro-plate Trades"; whilst before the Swansea local section there will be presented an essentially practical paper on "Rolling."

Copies of the complete programme may be obtained on application to the Secretary, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, London, S.W. 1, who will also be glad to forward particulars of membership of the Institute to anyone interested. A membership election is due to take place on October 27. Persons then elected will have the privilege—so we are informed—of taking part not only in the meetings of the Institute, but also in any of the local sections' meetings; further, they will receive copies of the Institute's bound volumes of proceedings and the monthly *Metallurgical Abstracts Journal.*

Sheet Annealing Furnaces, Past and Present*

By Dipl.-Ing. Friedrich Bleiman.

The author surveys the development of sheet annealing furnaces and indicates the outstanding features in modern construction.

IN the earliest type of sheet-annealing furnace the hearth of the heating chamber was a bar grate covered with fuel. When the fire was uniformly bright all over a thin layer of fine coal was spread on it, and the damper closed. The sheets were then placed on the fire and thus heated to 900° to 1,000° C. in a reducing atmosphere, the outlet for the products of combustion being through ports in the roof near the door, to prevent the passage of air from the door over the sheets. After withdrawal from the furnace the sheets were piled and allowed to cool slowly. The fuel consumption was high, 20 to 25% after allowing for the steam produced in the waste heat boiler placed above the furnace, while the sheets suffered more or less from surface defects. This type of furnace required a very large area in proportion to the output, which from a double furnace was about 20 tons of 1 mm. thick sheets per 24 hours.

A later development consisted of the employment of semi-gas firing with a brick hearth heated from the underside by the flame. The products of combustion entered the furnace chamber through ports near the door, travelling back over the sheets to outlet ports in the roof, and thence to the waste heat boiler. More frequently the fire was placed at the rear of the heating chamber, separated from it by a fire bridge, so that the flames travelled along the roof to the charging end. Here they passed to the underside of the hearth in order to provide heat through it to the bottom side of the sheets. Owing to mixture with air entering through the door, these bottom flues were found to cool the hearth instead of heating it, and were accordingly dispensed with. These furnaces with fires at the rear end tended to overheat the sheets near the bridge, which has necessitated the use of screening arches for some distance from it. In America underfeed stokers were very widely adopted in order to secure regular operation.

Gas firing has been successfully adopted with both dirty and clean gas. The latter provides the simplest and most perfect possibilities of annealing. A large number of mixing burners built into the rear wall will give any desired temperature, absolutely uniform over the whole hearth in small furnaces. With long furnaces auxiliary burners in the side walls are required, while for short furnaces baffle walls are employed to prevent direct impingement of the flame on the material being annealed. Using coke-oven gas, these furnaces are very efficient in regard to fuel consumption, while the cost of heating-up after stoppages is less than with other fuels, the furnace being ready for operation in a few hours.

Pulverised fuel has also been employed, using furnaces similar to those for semi-gas and coal firing, with suitably proportioned combustion chambers. This was abandoned owing to the difficulty with ash preventing that cleanliness of operation which is of the greatest importance in the production of high-grade sheets. In America also, where it was largely used, its use is being abandoned.

The furnaces so far considered were used for open annealing, and gave very irregular results from the point of view of scaling, in spite of a reducing atmosphere. The thin scale formed springs off in flakes when the sheets are subjected to work, even in the straightening machine. The loose scale is detrimental in the subsequent processes of manufacture; it interferes with welding, increases the wear of machines, and necessitates long time and heavy loss in pickling for galvanising and enamelling. To overcome this difficulty box annealing was adopted, the sheets being placed in piles weighing up to 15 tons, placed on a metal base with a heavy cover having a sand seal to keep out the products of combustion. With full charges the weight of the box is approximately equal to that of the sheets, causing a high fuel consumption, since the box, as well as the sheets, has to be heated up.

The simplest form of furnace for box annealing consists of a single chamber with from two to three times the volume of the box, the latter being run into the chamber on large balls on tracks on the floor. The products must surround the box, which has therefore to be eight or more inches above the floor. The best results are obtained by firing from both sides, with the outlet ports in the floor under the box. Two such furnaces are sometimes combined in a single block with a common division wall between the two chambers. This is of doubtful value, since each can only be fired from one side, while it is inconvenient to synchronise the operation. A pair of furnaces of this type will give an output of 12 tons per 24 hours with a fuel consumption of 14% in continuous operation. Heating up increases the consumption for a heat by 50%. An old type of furnace designed for continuous operation held four boxes, one in the high-temperature zone, two in the preheating zone heated by the products of combustion passing along the tunnel to outlet ports near the charging door, and the fourth in a cooling zone at the discharge end. This furnace gave an output of 20 to 30 tons per 24 hours, with a coal consumption of 12 to 16%. The

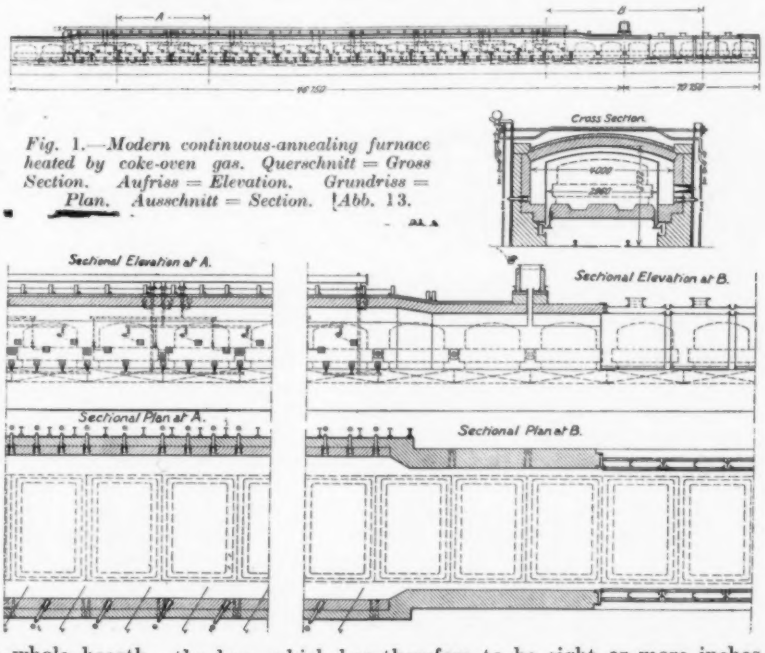


Fig. 1.—Modern continuous-annealing furnace heated by coke-oven gas. Querschnitt = Gross Section. Aufriss = Elevation. Grundriss = Plan. Ausschnitt = Section. [Abb. 13.

* Abstract from *Stahl und Eisen* of August 18, 1932, of a lecture at the meeting of the Association of German Ironmasters on April 14, 1932.

boxes were mounted on balls, which are not reliable even for short furnaces, and caused frequent interruptions.

In modern furnaces the boxes are placed on bogies with brick tops, in close contact with each other, and having sand seals along the sides. Owing to the short flame and the small quantity of the products of combustion when using coke-oven gas, pre-heating on the counter-current system cannot be attained. The result is so insignificant that it is necessary to fit burners in a portion of the pre-heating zone. In the high-temperature zone several rows of burners are used at different levels on both sides. A continuous record of the temperature in a box passing through a tunnel furnace showed that the bottom was within 50° to 30° C. of the top. A furnace of this type, 56 m. long, which holds 28 boxes, is shown in Fig. 1. This furnace was built for an output of 300 to 330 tons per 24 hours, the annealing time being 15 to 20 hours. The equivalent fuel consumption amounted to 8 to 10%.

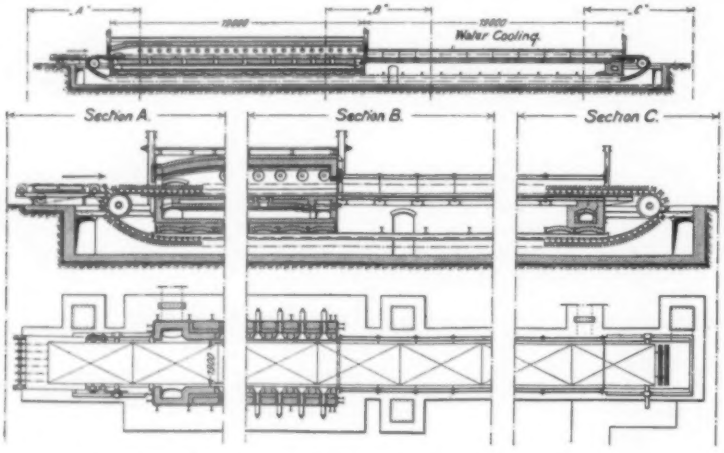


Fig. 2.—Continuous normalising furnace with chain conveyer. Ausschnitt = Section. Wasserkuhlung = Water cooling.

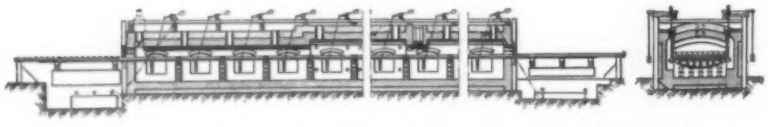


Fig. 3.—Continuous normalising furnace with walking beams, Surface Combustion Co.

In America the Dressler furnace has been well adopted. In this furnace the gases from the combustion chamber do not come into direct contact with the boxes, but pass into closed muffles along the sides, from the walls of which muffles heat is transmitted by radiation. The wastage of the boxes is thus kept low, and in consequence they can be made of lighter material, giving quicker heat transference and less dead weight to be heated. The difference in temperature between the top and bottom of a pile of sheets is very little—only some 10° C. for a height of 1,000 mm. The furnace is not so suitable for a varied annealing programme, since, contrary to a furnace with direct heating, the temperature distribution along the length of the furnace cannot be adjusted.

In spite of the advances made in the construction of continuous furnaces, the single-chamber furnace cannot be dispensed with for certain special qualities of sheet. Closer control of temperature and time is possible with it. Couples can be placed at any desired points within the pile and exact temperature curves obtained. This is very awkward to do in continuous furnaces, owing to the movement of the boxes, and cannot be adopted in regular practice. For this reason deep drawing sheets after the last cold working should only be annealed in single-chamber furnaces, the temperature being kept within a range of 10° C. The higher cost must be accepted for the production of a first-class deep drawing sheet.

Electrically heated furnaces have been employed, having a hood with heating coils on the inside. With a pile of 1,000 × 2,000 mm. sheets, weighing 5 tons, about 20 hours are required to heat to 800° C., the consumption being 400 kwh. per ton of sheet. To maintain this temperature requires 40 kw. The output of such a furnace only amounts to 60 tons of sheets in 30 working days. On account of the high capital and working costs the electric furnace has not yet been adopted for mass annealing.

The risk of sheets welding together in the pile at high temperatures imposes definite limits to the use of box annealing. The temperature of the first annealing should not exceed 760° C. This, followed by slow cooling, gives a sheet which meets all usual demands, but it is not sufficient for deep drawing sheets. The more stringent requirements of the latter have led to the use of normalising instead of annealing. This consists in heating to just above the upper critical range, about 900° C., followed by quick cooling to 700° C., and then somewhat slower cooling to avoid hardening.

The normalising of the very highest grades is carried out in in-and-out furnaces, five to eight sheets being placed on the hearth. The top surface is protected by covering with a waster sheet. The sheets are held at 960° C. for 4 to 5 mins. per mm. thickness. The packets from several furnaces are piled together in order to prevent chilling in the air and excessive scaling. With careful supervision this method gives very reliable deep drawing quality, but it is too expensive for automobile sheets, for which continuous furnaces have been introduced.

The first continuous normalising furnace, 1,650 mm. wide by 30 m. long, built five years ago by the Surface Combustion Co., constituted a very notable advance in the heat-treating of thin sheets, and is still in operation. The sheets are sent through the tunnel furnace on a mechanically operated roller hearth, either singly or in packets of two or three sheets, according to the thickness, being laid on a dummy sheet to prevent damage by the rollers. The furnace is heated by coke-oven gas. There is a dividing curtain wall between the heating and cooling zones, which restricts the flow of the products of combustion and expedites the cooling.

The Kathner furnace introduced a number of improvements in the construction and operation of the normalising furnace. The cooling zone is kept especially low, so that the gases flow around the sheets, providing better protection against scaling. A movable door is provided between the two zones to regulate the rate of initial cooling, since the quicker this takes place the finer is the structure.

The simplest continuous furnace from the point of view of construction is that using travelling chains, as shown in Fig. 2. Depending on the width of the furnace, there are two or more chains side by side. Since they lose a large portion of their heat in returning outside the furnace, it is necessary to make provision for raising them quickly to the required temperature on re-entrance, so that the sheet shall not be subjected to a lower temperature at the points of contact than elsewhere.

The walking beam furnace, Fig. 3, is a big advance in the construction of continuous normalising furnaces. The hearth consists of longitudinal beams supported by brick piers between which are movable beams. These raise the sheets off the stationary beams, carry them forward, and

(*Continued on page* 197.)

METALLURGIA

The British Journal of Metals

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Subscription Rates throughout the World - - 24/- per annum, Post free.

Published Monthly by the Proprietors, THE KENNEDY PRESS LIMITED, at 21, Albion Street, Gaythorn, Manchester.

Telegrams: "Kenpred," Manchester. *Telephone: Central* 0098.

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

IMPLIED WARRANTY.

RECENT inquiries, in several different localities throughout the country serve to establish a doubt as to whether suppliers in the engineering and metallurgical industries are fully aware of the extent of their liability under the Sale of Goods Act. Apparently, few manufacturing firms take the precaution to safeguard themselves against possible heavy penalties, notwithstanding that the publication, as a condition of sale, of a clause defining the extent to which the supplier may be held liable, is all that is necessary. In the absence of any limiting clause, the user, by virtue of the "implied warranty" recognised in law, may assume, rightly, that any supplies will fulfil all conditions of suitability for the purpose disclosed. The failure of any supplies may be the cause of the supplier being penalised, not only to the extent of repair or replacement, but of heavy payments, claimed as consequential damages. Payment may be demanded, under Common Law ruling, of such an amount as will place the customer in the same financial position as he would have been had the supplies not proved defective.

Many firms are under the erroneous impression that they are safeguarded by the contractual implications of trade custom, and this idea prevails notwithstanding the fact that such is not necessarily good in law. The reader's attention is called to a recent ruling delivered by Mr. Justice Roche in the King's Bench Division of the High Court.

Briefly stated, the case was one in which Messrs. Cammell Laird and Co., Ltd., shipbuilders of Birkenhead, claimed damages against the Manganese, Bronze and Brass Co., Ltd., propeller manufacturers, of London, for alleged breach of contract in connection with the supply of a marine propeller.

The defendants pleaded that the propeller was manufactured and was, in all respects, in accordance with the specification and design accompanying the order. Breach of contract was denied, and they counterclaimed for the cost of two replace propellers supplied to the plaintiffs. The hearing of the case, which commenced on July 6, was reported at considerable length in the *Journal of Commerce and Shipping*.

The breach of contract complained of was in regard to a propeller which was said to have proved in service "to be unsatisfactory and unsuitable," in the respect that at certain speeds it gave rise to an "exceptional and unusual noise" of the nature of humming or "singing."

Mr. Justice Roche, in giving judgment, said that there had been much conflicting evidence. He was, however, satisfied that the metal of all three propellers was of the quality called for in the customer's specification, and he did not find the trouble to be due, as had been suggested, to hidden defects in any of the castings. He thought the root cause of the trouble was to be found in the edge thickness of the blades in the case of the two unacceptable propellers, although he did not imply negligence on the part of the manufacturer of the propellers. He found there was an *implied warranty* of the fitness of a propeller for a specific purpose, the plaintiff company having placed the order with a propeller manufacturer of good repute,—and the warranty had been broken. He pronounced judgment to the effect that the plaintiffs were entitled to succeed on the claim for *damages*, with costs. The defendants did not succeed in respect to the counterclaim for payment for the two replace propellers.

It is because of the fact that many suppliers fail to recognise that their liability in law, under "implied warranty," is not confined only to replacements, free of charge, of defective supplies, but may be extended to include also payment of all those charges which may be claimed under the head of "damages," that the writer urges immediate action on the part of suppliers and the drawing-up amongst themselves of an acceptable safeguarding clause.

It is quite conceivable that in some instances, although a batch of goods may of itself have, comparatively, only a small sale value, the user, in the event of his finding that the supplies are "unsatisfactory and unsuitable" for the purpose disclosed, is in a position to demand damages from the manufacturer out of all reasonable proportion to the value of the order placed.

In the case of foundry products, it is gathered that the custom of the trade limits the liability of the founder "to replacement, free of charge, of any casting proved to the satisfaction of both parties to be defective"; no payment being made even for any fitting or machining work done on the rejected castings at the customer's works.

It is not suggested by the writer that at all times and under all conditions payment for fitting and machining work should be withheld, but rather that any money paid over for such work shall be considered as an *ex gratia* payment and not as a liability in law. Such an understanding between manufacturer and user as is implied in the foregoing suggestion would undoubtedly tend to foster a better relationship between the two parties than can possibly obtain under the somewhat one-sided benefiting of the Sale of Goods Act. Obviously, the interests of the supplier of semi-manufactured goods must be safeguarded by some such arrangement as that suggested, as otherwise he may find himself called upon to pay extravagant charges for work done, and in the performance of which he has had no control whatever.

In this connection, it is not within the province of the writer to draft the actual wording of a satisfactory clause, as a condition of sale, for adoption by the trade. Such a step would be presumptuous in view of the fact that the trade has organisations to whose care the drafting of an acceptable safeguarding clause may be safely left.

The writer is aware that some firms have already adopted and published a safeguarding clause. Immediately following the report of the judgment of Mr. Justice Roche, in the propeller case, of which previous mention has been made by the writer, the attention of the writer was drawn to the publication in a contemporary journal of the printed conditions of sale appearing on the tender form of a Sheffield Steel Co., in which is included a clause worded as follows: "In lieu of any warranty or other liability implied by law, the liability of the Company in respect to any defect or failure in the contract work is intended to and shall be limited to its making any necessary replacements, repairs, or restorations to the contract work, *and it shall not be liable for any consequential* or *further damages*".

The italics are the writer's. It is on this question of "damages," and its comprehensiveness, that the writer issues a warning. Unless the supplier publishes a negation of liability, as a condition of sale, he may be involved in heavy unexpected liabilities. ***Verbum satis sapienti.***

THE OTTAWA SCHEDULES.

THE eagerly awaited summary of proceedings and copies of trade agreements of the Ottawa Conference have just been published. In addition to the agreements already made known, the publication includes the schedules in terms of which these agreements have been implemented. These schedules, which indicate new scales of import duties to be imposed by the Dominions, have been rather anxiously awaited by British traders. The Dominions agree to maintain protective barriers against foreign countries, in respect of various commodities, in return for the imposition of new taxes on foreign wheat and other foodstuffs by Britain.

Separate agreements have been entered into with Canada, Australia, New Zealand, Newfoundland, South Africa, India, and Southern Rhodesia, and with the schedules now available traders will be better able to form a considered opinion of the achievement of the Conference. The lists indicate that the concessions made by the Dominions are greater and cover a wider range than was anticipated. The agreement with Canada, for instance, provides for the modification of Canadian duties on 215 exports. Existing duties on British exports will be reduced on 132 types of goods, while in respect of 79 types of goods British exports will be admitted into Canada duty free. In the case of 83 types of products no direct change is made, but duties on similar products from competing countries will be increased, thus increasing the preference margin to British products.

Many items of interest to the British iron and steel trades have been amicably arranged between the iron and steel interests of Britain and Canada. Useful concessions have been made on such manufactured articles as cutlery, machinery, and wire products. Of the iron and steel imports to Canada many have been placed on the free list. The latter include various classifications of sheets, bars, rods of iron and steel; sheets, plates, and other standard forms of rust-, acid-, and heat-resisting steel, and forgings of iron and steel. The cutlery trade, too, has benefited, as formerly this trade was subject to a flat rate *ad valorem* duty of 20%. Under the new agreement this has been reduced.

Australia undertakes to give British products certain minimum preferences, ranging from 15 to 20%, and to maintain existing preferences which already are greater. It will be remembered that a pledge was given at the last election in Australia not to reduce duties except on the recommendation of the Tariff Board. Reductions of duty, however, have already begun, and a promise has been given to abolish, as soon as possible, the existing prohibitions on the importation of certain goods from Great Britain. The "primage" duties have also been terminated. Among the manufactured goods to benefit by these reductions are corrugated and galvanised iron, steel sheet, and plates, dynamo machinery, and transformers.

New Zealand agrees to modifications in basic import duties on a number of commodities, but there is probably less difference made by the schedule than with those of other Dominions. This is due to the fact that goodwill has always been shown to British traders by New Zealand, and there is little room for further concessions. A number of new and increased preferences are granted by South Africa, and in order that these can be effected efforts are being made to terminate her commitment to Germany. Newfoundland grants preferences for the first time, while India has found it possible to agree to make substantial concessions.

The fuller information now available shows that the Conference has achieved a degree of success which should facilitate economic development within the Empire. It now depends upon the ingenuity and capacity of producers and manufacturers what use is made of the facilities and to what extent development will follow. Full appreciation of the possibilities should make Empire trading the success it ought to be.

Forthcoming Meetings

THE INSTITUTION OF MECHANICAL ENGINEERS.

Oct. 21. Annual dinner.

Oct. 28. General meeting. Presidential address by William Taylor, O.B.E.

Nov. 4. Thomas Hawksley Lecture by Professor Lord Rutherford, O.M., M.A., LL.D., D.Sc., F.R.S. Subject: "Atomic Projectiles and Their Application."

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Oct. 21. Presidential address, by R. J. Walker, C.B.E.

Oct. 28. Andrew Laing Lecture. The opening lecture, enitled "The Work of Andrew Laing," will be delivered by the Engineer-in-Chief of the Fleet, Eng. Vice-Admiral Sir Reginald Skelton, K.C.B., C.B.E., D.S.O.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Oct. 25. "A Note on the Development and Operating Results of Bauer-Wach Installations," by R. J. Butler.

Nov. 8. "Ship Furnishing and Decoration: A Plea for Modernity."

THE INSTITUTE OF METALS.

London Section.

Nov. 10. "Non-ferrous Metals and Alloys in Railway Engineering," by Sir Henry Fowler, K.B.E., LL.D., D.Sc.

Scottish Section.

Nov. 14. "The Production of Hot Brass Pressings," by J. W. N. Beard.

Sheffield Section.

Nov. 3. "Nickel-silver Alloys for the Electroplate Trades," by W. R. Barclay, O.B.E.

Nov. 11. "Rolling-mill Practice and Cluster Mills," by E. Williams.

Swansea Section.

Nov. 10. "Some Stainless Alloys," by L. B. Pfeil, D.Sc.

CO-ORDINATING COMMITTEE.

Oct. 20. Inaugural address, by Sir Charles Grant-Robertson, at the University, Birmingham.

Nov. 8. "High Elastic Limit Mild Steel," by F. G. Martin, F.I.C., at the Girls' High School, Dudley.

INSTITUTE OF BRITISH FOUNDRYMEN.

Birmingham.

Nov. 4.—"Properties of Pig Irons," by J. E. Hurst.

East Midlands.

Oct. 22.—"Some Factors Influencing the Production of Sound Non-Ferrous Castings," by F. H. Rowe, B.Sc.

Lincolnshire.

Nov. 5.—"High Strength Light Alloys," by W. C. Devereux.

Lancashire.

Nov. 5.—"Contraction, Distortion and Camber in Grey Iron Castings," by E. Longden.

Burnley.

Nov. 10.—"Craftsmen or Specialists," by J. J. Clark.

Preston.

Nov. 4.—"Source and Elimination of Blow Holes, Cracks and Drawn Holes," by C. H. Kain.

London.

Nov. 10.—"Fuel Oil as Applied to the Ferrous and Non-Ferrous Foundry Industries," by T. F. Unwin.

Middlesborough.

Oct. 28.—"Some Aspects of Jobbing Moulding with some Gating Suggestions," by S. Southcott.

Nov. 11.—"Furnace Linings," by J. F. Hyslop.

Newcastle-on-Tyne.

Oct. 27.—"The Manufacture of the Mammoth Cunard Castings," by F. Swift.

Scottish.

Oct. 22.—"The Manufacture of Cast Iron in the Bracklesburg Furnace," by P. M. Macnair, Ph.D.

Nov. 5.—"Plastic Patterns in General Foundry Practice," by Robert Ballantine.

Sheffield.

Oct. 21.—"The Use of Refractory Materials in a Foundry," by J. G. A. Skerl, D.Sc.

West Riding.

Nov. 12.—Discussion: "Iron Castings versus Fabricated Parts," by A. W. Walker, and E. B. Shore.

Correspondence.

Standardising Foundry Pig Iron.

October 4, 1932.

The Editor, METALLURGIA.

Dear Sir,—We have read with much interest the article on "Standardising Foundry Pig Iron," and also the comments published in your September issue.

As we read it, the article is concerned more particularly with the growing practice on the part of blast-furnace owners of attempting to supply iron to a wide range of chemical compositions, which necessitate frequent changes in the operations of furnaces. It suggests that such changes may not be economical, as they retard output and produce a proportion of off-grade iron, and, for these reasons, result in an increase in the production costs.

We think that in regarding your article as a plea for grading by chemical analyses as opposed to grading by fracture, some of your correspondents have missed the main point.

It is undoubtedly a fact that many blast-furnace owners have been tempted, through a shortage of orders for what may be described as their standard types, to produce iron of different qualities. It is probably a fact that the practice of making several types of iron of widely different composition in one blast-furnace is, for the reasons mentioned in your article, uneconomic. If, therefore, it could be visualised that each furnace in the country was steadily producing a type of iron for which it was best fitted, having regard to local supplies of material, etc., working on a standardised ore and fuel burden, and operating at a rate for which the plant was best fitted, without change, other than those imposed by circumstances outside the owner's control, it is easy to see the possibilities of reducing the costs of production.

This standardised iron would naturally vary a little, notably in silicon, but could be sorted into grades, either by chemical analysis or fracture, or even by both methods, according to the requirements of the trade. More regular working conditions would tend to keep variation in quality from each furnace within narrower limits, to the benefit of the foundryman who, above all, wants regularity, and will find a way to use the metal to the best advantage.

So far we have been referring to ordinary types of foundry iron, suitable for the production of castings where the price of iron is of vital importance. High-duty castings are in a different category, and the purposes for which they are used, and the services they have to perform, dictate the composition and strength of the metal. Iron suitable for many of those conditions cannot be produced direct from the blast-furnace, and the demand has to be met either by scientific methods in the case of large foundries, or by the specialist producers of refined pig irons.

Concentration on the production of standard types of pig iron at the cheapest possible price by the blast-furnace owners, coupled with an increased demand for, and therefore cheaper cost of, refined iron of various types, could only tend towards cheaper costs of iron of all qualities, to the ultimate benefit of both the maker and the user.—Yours, etc.

Per pro BRADLEY AND FOSTER, LTD.,
Darlaston. J. E. HURST, Technical Director.

Refractory Materials for Air-Heating Furnaces.

October 11, 1932.

The Editor, METALLURGIA.

Dear Sir,—In the article by Mr. Searle, dealing with refractory materials for air-heating furnaces, published in your August issue, reference is made to the high heat conductivity and refractoriness of Carborundum for recuperators. In this connection it will be of interest to mention Carbofrax heat-transfer tubes embodied in a recuperator produced under Fitch patents. The air to be heated is forced or drawn through the tubes between their inner surface and fireclay corebusters which are centred in them. In this way the air has intimate contact with the walls of the Carbofrax tubes, and heat from the gases of combustion which surround them is efficiently transferred.

These Carbofrax tubes, which comprise the heat-transfer elements, are manufactured from Carborundum brand silicon carbide. This material has a high thermal conductivity, the curve being a straight line between 105·5 B.th.u. per hour per square foot per inch of thickness per °F. difference in temperature at 1,100° F., and 112·5 B.th.u. at 2,900 °F. It is capable of withstanding the highest temperatures existing in industrial heating operations. It is less permeable to gases than most other refractories, and it has an average modulus of rupture of approximately 900 lb. per sq. in. at a temperature of 1,350° C. (2,462° F.), while its crushing strength at this temperature is in excess of 10,000 lb. per sq. in.

These tubes simplify many heat-transfer problems, and they are valuable because of the absence of danger of their becoming damaged by overheating due to any cause, or by the effects of corrosive gases.

A number of air-heating units have been built by the Carborundum Co., Ltd., as part of furnace plants they have erected, and in all cases, after years of use, have given every satisfaction.—Yours, etc., F. WATERHOUSE.
Refractory Department,
The Carborundum Co., Ltd., Trafford Park, Manchester.

Metallurgical Problems.

SPEAKING on the subject of metallurgy, Mr. A. A. Jude, M.I.Mech.E., in his presidential address to the Birmingham Metallurgical Society, said there was now an enormous complexity in metallurgical problems, but at the same time there appeared to be some attempt to produce the ideal metal. The properties which such a metal must possess would be many; it would have to cast easily, forge easily, have a negligible coefficient of expansion by heat, would have to be easily machinable, would have to possess a working tensile strength of about twenty tons per square inch, it would have to keep its properties at any temperature, apart from many other equally necessary properties. The question was, however, whether anyone really wished to produce such a metal; no one wished a metal to last for ever or even for a generation. Heat-treatment was a process designed to prolong the life of the metal, but what they required were metals in the most stable form, and this was not to be found in the "highly strung" condition of heat-treated metal. He would like to see the elimination of what he might term downward heat-treatment, and upward heat-treatment substituted.

On every side one was confronted, not only with the complex but with the "contraplex." By this he meant the crave for endurance on the one hand and the craving for destruction on the other hand. Take the subject of waste, for instance. Waste was the production which they did not desire to produce, such as the tops of ingots, etc.; but what the engineer called waste was not waste to other people, who were willing to buy it back at their own price. Waste was merely relative.

The Institution of Welding Engineers. Proceedings 1931—1932. Vol. IV.

THIS volume includes the papers presented at the ordinary general meetings of the Institution during the past session, and also the discussions which developed from them. Some ten papers are given on a wide range of subjects dealing with the science and practice of welding by various systems; these include autogenous welding of lead and its alloys, welding in boilerworks practice, welding nickel and its non-ferrous alloys, the fabrication of stainless steel by welding, arc-welding structural steel, the welding of copper with the oxy-acetylene flame, all of which have been prepared by experts.

The Institution of Welding Engineers, 30, Red Lion Square, London, W.C. 1. Price to non-members, 3/– post free.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part XIV.—Cold-Rolling Mills.—Contd.

Two-high Strip Mills.

Two-high strip mills are employed for roughing, running down, and finish rolling in the production of aluminium coil. Both reversing and non-reversing strip mills are used. The former have been promoted mainly by builders in Continental Europe, and such mills have been installed in both European and American plants. Non-reversing strip mills may be driven by individual motor or a number may be coupled in a train ; reversing strip mills are individually motor driven. Reversing strip mills are possibly better suited for preliminary roughing than for finishing, but are used for both purposes. They are more expensive as regards first cost and maintenance than the non-reversing type. Two-high strip mills are fitted with rolls measuring from say, 18 in. to 36 in. in face length. Typical roll sizes are as follows :—12 in. by 20 in., 15 in. by 20 in., 14 in. by 26 in., 16 in. by 24 in., 18 in. by 24 in., 20 in. by 30 in., and 22 in. by 36 in. (diameters by face lengths, respectively). Strip mills may, of course, be fitted with rolls measuring less than 18 in. in face length. Narrow aluminium coil is, however, normally rolled in multiple widths so that short-bodied rolls are not especially needed.

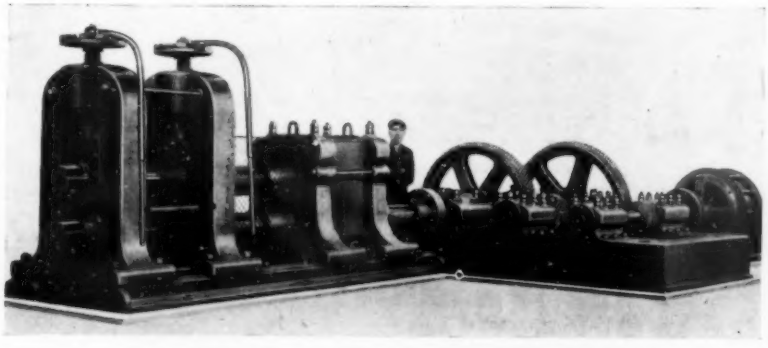


Fig. 4.—Two-high non-reversing strip mill, heavy roughing type (Philadelphia Roll and Machine Co.).

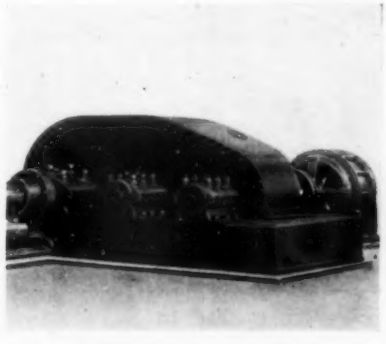


Fig. 5.—Gear unit covered.

The general description given above as regards design and materials of construction for sheet mills apply more or less also to strip mills. Modern strip mills are high-speed machines and are equipped with automatic winding devices for handling the long lengths of strip. Sheet mills run at slower speeds, and the stock is handled on tables. In the preliminary stages of roughing coil slabs, the material may be run " in the flat," being handled on tables until a certain thickness is reached. Then the automatic coiler may be locked into working position, and the material coiled on the last roughing pass. Descriptions of some strip mills have been given recently by Davies.[4]

Fig. 4 shows a two-high non-reversing strip mill of the heavy roughing type, suitable for running down aluminium coil slabs. Fig. 5 shows the same mill with the reduction unit covered. Description as given by the builders is as follows :—Shoes, roll and pinion housings, pinion housing caps, spindle and coupling boxes are made of air-furnace iron. The roll housings are of the closed-top type with top screw-down operated by means of handwheel or wrench. The screw is of high-carbon forged steel, and the nut is air-furnace iron. Roll-housing fillings are cast iron with phosphor-bronze bearings. Rolls are chilled cast iron. The top roll is properly counterbalanced by means of steel-yards, and the counterweights are suspended beneath the roll housings. Mill pinions are made of cast open-hearth steel, having cast double helical teeth. Pinion bearings are babbitted cast iron. The gear drive consists of a four-piece frame made of air-furnace iron and is bolted and keyed together so as to form a unit construction. The mainshaft bearings are cast on the frame, and the intermediate and motor-pinion bearings are bolted to the frame. These bearings are babbitted. All shafting is made of forged steel. Drive pinions are made of cast or forged steel and gears of cast steel ; these have machine-cut double helical teeth. A steel plate gear casing, made in two halves, is secured to the frame, permitting the gears to run in oil. The mill coupling is made in two halves, one keyed on the mainshaft and the other half carrying the pinion wabbler ; this coupling is made of cast steel, and the halves are bolted together. A Francke flexible coupling connects the motor-armature shaft and the gear unit. Mills similar to the above may be considered as typical of those offered by American makers upwards of 15 years ago.

Reversing strip mills for roughing, running-down and finishing aluminium coil have been coming into favour of recent years. A large number of mills of this type have been supplied to the aluminium rolling industry by Schmitz and Co., Thun (Gvatt), Switzerland. Following is a short description of the construction of reversing strip mills of late design as made by this builder :—

The mills are built in large part of wrought and cast steel rather than cast iron, so as to ensure against breakage. Thus, all the main gears, pinions, shaftings, couplings, roll housings, entrance tables, central adjustment, etc., are made of steel. Mills are equipped with forged and heat-treated steel rolls of various sizes, and provision is made for internal water cooling. Roll bearings are made of phosphor bronze ; provision is made for internal water cooling, and lubrication is by force feed. The mills driven by individual motor through a reduction unit. When driven by a normal motor, change in direction of rotation of the rolls is effected by means of two friction clutches. The rolls turn one way or the other, depending upon which clutch is thrown into gear. Otherwise, drive is by reversible motor. Reduction-unit gears are of the herringbone type, cut in steel. The unit is housed in a dust- and oil-proof box and has forced lubrication. These mills are also built in the open-gear type, in which case the gears have helical teeth. The herringbone gear is superior. Mill pinions are

4 C. E. Davies, " Development in High Speed Strip Rolling," *The Metal Industry* (London), vol. 33, November 2, 1928, pp. 413–416. C. E. Davies, " Modern Practice in the Cold Rolling of Non-Ferrous Metals," METALLURGIA, vol. 2, No. 10, August, 1930, pp. 145–146 ; No. 11, September, 1930, pp. 179–182.

5 C. E. Davies, *op. cit.*

Fig. 6.—Two-high reversing mill, heavy roughing type (Fried. Krupp, Grusonwerk).

furnished in the herringbone type. Shaftings are of steel and run in roller bearings arranged to compensate for wear. The upper roll and breaking pins are balanced. Adjustment of the rolls is made by direct motor drive through worm gearing, and an extra pair of gears is provided so that the rolls can be regulated when under pressure. The extra pair of gears can be disengaged by a lever, this operating as a quick release. Each screw can be regulated separately by actuating the corresponding hand lever. These mills are all equipped with a flexible coupling to take up the shocks of stopping and starting.

Special winding (coiling) devices are provided on each side of the mill. These devices may be rotated both clockwise and counter-clockwise, so that they can be used for both winding and unwinding the strips. Power is transmitted to the winding devices from the main drive shafting by means of a friction clutch with leather-covered cone. The friction clutches which drive the winding drums are thrown in and out of gear by means of a treadle. Powerful brakes are applied to the drum spindles so that the necessary tension can be applied to the strip when the winding device is operating as a feeding reel. The brake is combined with the friction clutch in such a way that one or the other is automatically engaged. If the drum operates as a winding device, the brake is disengaged by treadle, and the friction clutch is thrown out of gear. If the drum operates as an unwinding reel, the friction clutch is disengeged by treadle, and the brake takes hold. The shafting of the winding drum is equipped with an outside bearing to ensure proper alignment. This bearing can be swung aside so that the coil can be removed fromthe drum.

Fig. 6 shows a view of a two-high reversing mill suitable for the heavy roughing of strip slabs. This mill may also be used for hot breaking down. Fig. 7 shows a view of a two-high reversing mill suitable for running-down and finishing coil. Brief description of these mills, as built about six years ago by Fried. Krupp Grusonwerk, Essen, Germany, is as follows :—

Mills are supplied as a rule with cast hardened steel rolls but may be furnished with chilled cast-iron rolls. The lower roll runs in movable chocks, which automatically give to the flexure of the rolls. The upper roll runs in suspension bearings. All cast steel rolls are bored for water cooling. The bearings are also arranged for water cooling. Mills may be furnished with a central lubricating system which automatically cuts out when the mill is not operating. Pinions are made of forged steel and have machine-cut helical teeth. They run in an oilbath in a completely enclosed housing. Reduction-unit gears have machine-cut helical teeth. One of the countershafts is fitted with a reversing friction clutch of the Isfort type ; the brake block can be replaced easily and quickly without dismantling the clutch. This clutch does not require any special lubrication. The roll and pinion housings are mounted on an elevated bedplate, to which are likewise attached the bearings for the countershafts. The roll housings are steel castings. All shafts are made of forged open-hearth steel and run in ring-lubricating bearings. They are ground at the bearing surfaces. Mills are supplied with either key screw-down spindles or central adjusting gear. Small adjustments may be made while the mill is in operation under load without disengaging the tooth gearing. With the central adjusting arrangement, either screw can also be set by separate handwheel. Both handwheels can be promptly coupled by means of a hand-lever, when both screws are to be jointly raised or lowered. In Fig. 6 the mill is shown as fitted with roller tables on either side. Coiling devices may also be provided, as shown in Fig. 7. The coiling drums serve both for winding and unwinding. The driving gear of the coiling attachments is fitted with a special clutch similar to the Uhlhorn clutch or is provided with an electromagnetic clutch. When an electromagnetic clutch is used, the specification includes a controller by means of which the energising current can be regulated so as to impart tension to the strip.

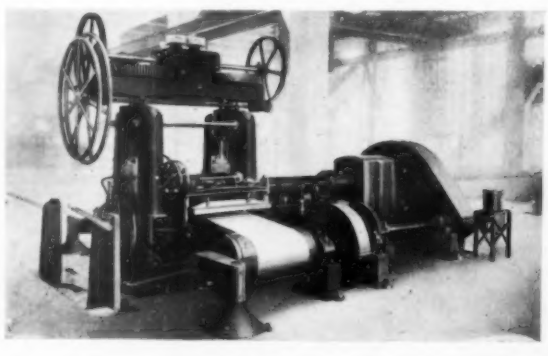
Fig. 4 of a previous article of this series (Part XII.—Slabbing and Roughing) shows a view of a two-high non-reversing mill roughing coil slabs. Figs. 5 and 6 of another previous article (Part XIII.—Finish Rolling) show views of similar mills being used for the finish rolling of coil.

Rolling speeds in processing aluminium coil vary considerably. Roughing is done ordinarily at considerably slower speeds than finishing. At one plant, heavy roughing is done on a mill equipped with rolls 22 in. in diameter, rotating at 24 r.p.m. This is equivalent to a peripheral speed of about 138 ft. per min. In the same plant the second roughing operations, running down and finishing are carried out at speeds ranging from 200 ft. to 350 ft. per min. American practice generally has favoured the cold rolling of strip stock at high speeds. Still higher speeds will undoubtedly be used with the development of more efficient lubrication methods for ordinary neck brasses and the application of roller bearings. Davies[5] has stressed the economic importance of high rolling speeds.

Two-high Continuous Mills.

Two-high continuous mills have been employed to some extent for roughing both sheet and coil slabs. Such mills may be equipped with rolls measuring 36 in. to 60 in. in face length. The number of stands may be from four to eight. These mills are well adapted to preliminary roughing, which may be carried out either hot or cold. The two-high continuous mill consists of a number of two-high non-reversing stands closely coupled in tandem. One motor serves to drive all the stands. Roll speeds of the successive stands are regulated according to the amount of reduction and extension of the slab. At one plant there is a four-stand continuous mill equipped with rolls measuring 28 in. in diameter by 36 in. long. The roll speeds for the successive stands are as follows :—No. 1, 9 r.p.m. ; No. 2, 12 r.p.m. ; No. 3, 18 r.p.m. ; and No. 4, 23 r.p.m. In another plant there is an eight-stand mill fitted with rolls measuring 30 in. in diameter by 60 in. long. The roll speeds vary from about 10 r.p.m. in the first stand to 25 r.p.m. in the last stand. Stock delivered from the last stand of a continuous mill may be edge trimmed on a heavy-duty slitter.

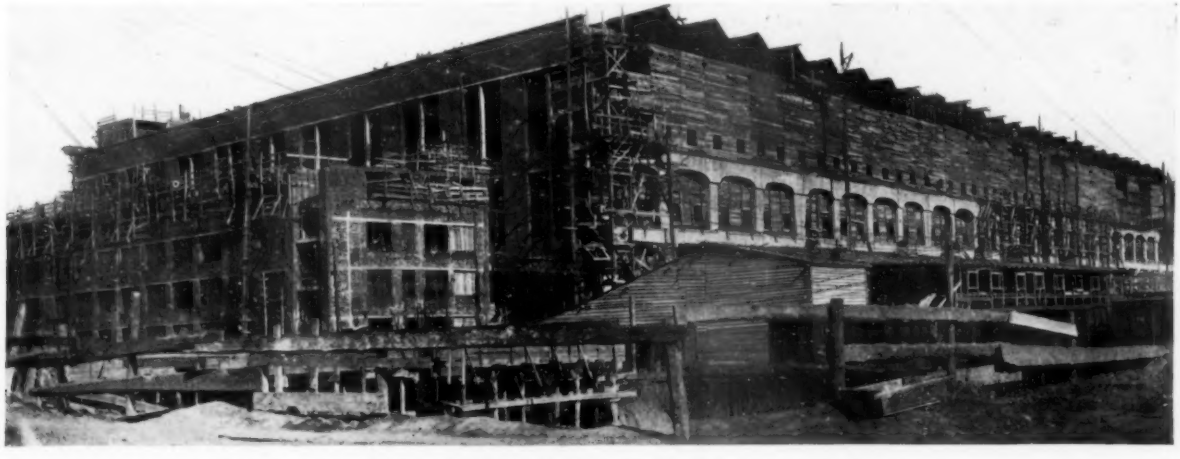
Fig. 7.—Two-high reversing strip mill (Fred. Krupp, Grusonwerk).



Kharkov Turbo-Generator Works

Russia is in the throes of an economic and social experiment of unprecedented vastness and complexity, the stupendous character of which is presenting formidable difficulties. Rich in national resources, this vast territory, formerly largely devoted to agriculture, is being industrialised according to a comprehensive plan, and huge construction programmes of vital importance to the economic scheme are gradually being completed. In this article turbo-generator works of immense capacity are discussed.

THE first completed section of the Kharkov turbo-generator works has recently been put into operation. These works are designed, and when finally completed will be equipped, for the construction of turbines and generators having a capacity ranging from 50,000 to 200,000 kw. The building is of immense size, and one of the largest in the U.S.S.R. It measures 365 metres in length by 88 metres wide. According to plan, these new works will, in 1933, have an output of turbo-generators of an aggregate capacity of 1,500,000 kw., and by 1935 they are expected to be capable of producing units aggregating 2,300,000 kw.



Some of the main buildings of the Kharkov Turbo-Generator Works in course of construction.

The stupendous character of this enterprise will be appreciated when comparison is made with the capacity of similar works of the General Electric Co. of America, which is reputed to have the largest works of this character in the world ; in its best years these works produced turbo-generators approximating to an average capacity of 1,000,000 kw. a year.

It is significant that the Kharkov works has been built in the Ukraine, which, under the old regime, was not allowed to develop its own industries ; under present conditions the Ukraine has become a very powerful economic unit, and is advancing more rapidly in its industrialisation than other republics of the U.S.S.R. It is of interest to note that in 1924 capital investments in the Ukrainian industries amounted to 54·7 million roubles ; in 1927 they were increased to 285 million roubles, and to 1,121 million roubles in 1931. The figures indicate the rapid rate of development of this republic's industries.

The building of the Kharkov turbo-generator works is a further step on the road to industrialisation, and when completed and equipped will meet the requirements for power plant included in the huge development plan. Already arrangements are made for the construction of a number of units to supply electric power and assist in developing the vast regions planned. The smallest of these units is one of 50,000 kw. capacity. This will equal the full generating capacity of the Volkhov power station, supplying electricity to all the industries in and about Leningrad, or as much as the Kharkov power station and subsidiary stations now supplying electricity to the capital of the Ukraine. The construction of turbo-generators of 200,000 kw. capacity is also contemplated, larger than any yet built, each capable of developing about half the total output of electric power in pre-war Russia.

The extent and immensity of the programme will be better understood when it is remembered that the largest power station in the world, that for New York, has a capacity of 160,000 kw., and this is produced by two generators, each having a capacity of 80,000 kw. It will be appreciated that many problems of a very formidable character will be encountered before this programme is ultimately completed, but the whole scheme is being tackled with remarkable courage.

Every effort is being made to equip these works with machine tools of great power and modern design. Large turbo-generators, such as are contemplated, will need very large and powerful machines for their construction ; this is indicated by a typical installation which may be mentioned. This is a longitudinal planing machine, the bed of which is 22 metres long; the height of the machine is about 4·3 metres and 5 metres wide. The weight of this machine is approximately 282 tons. A lathe installed, driven by a 150-h.p. motor, is capable of handling work up to 10 metres in diameter. This machine is said to weigh 461 tons. Other machines have been built on similar lines in order to cope with the structural parts for such large power plants. The first section of the works now open has an installation of 280 lathes.

The transporting facilities in these works have been designed on the same colossal lines, and in the main body of the building a crane with a lifting capacity of 200 tons will be installed. Already twenty cranes have been installed in the first section, having lifting capacities ranging from 20 tons upwards.

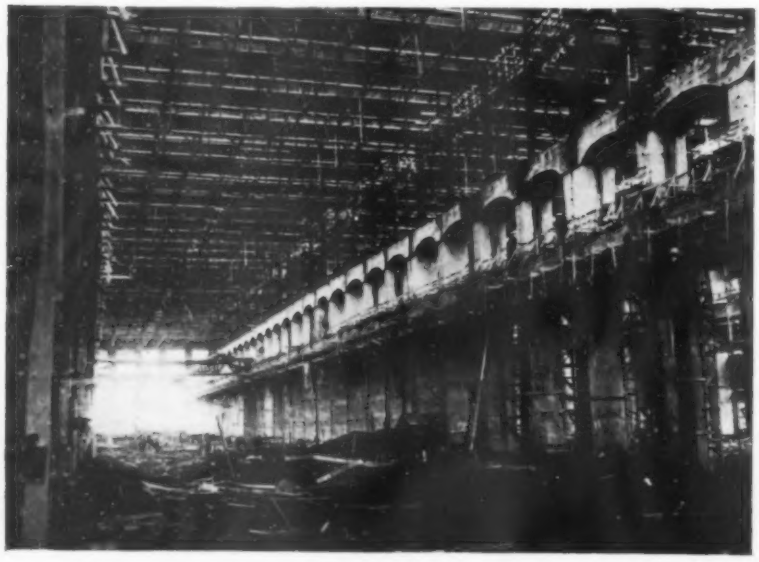
In keeping with modern progress, the works will include special research laboratories, which will not only assist materially in maintaining the standard of products, but

Erecting a conveyer in the new works while building is proceeding.

in developing the technique of production. The works will have its own mechanical, electro-technical, metallurgical, chemical, and X-ray laboratories, while in addition it will have a control and research station with highly technical control-test equipment.

Owing to the high degree of rationalisation and to the fact that all processes are mechanised, the works during this year, will only employ a staff of about 3,100 workers, engineers, and clerks. Later, when the works are in full operation it is expected that a staff of 5,000 will be employed. The main staff is being trained in the Kharkov and Leningrad works, while about 150 skilled workers are being imported to form a nucleus of trained operators. The problem of training additions to the staff is being faced with determination and resource, and a workers' faculty (technical school) is being established to accommodate pupils which will serve as a permanent training centre for the staff of the new works. The cultural and housing needs of the workers have not been overlooked ; a sum of ten million roubles has been allocated for this purpose, while a workers' club is to be erected at a cost of two million roubles, and a million roubles is being expended on infant crèches and other facilities for children.

Interior view of one of the main shops at the Kharkov Turbo-Generator Works during building.



What these new works mean to the Ukraine will be understood when it is realised that the thirty-three electric power stations put into operation in the Soviet Union in 1931 (the Leningrad, Kashir, Shatura, Nigres, Stalingrad, Shterov, Magnitogorsk, etc.) have an aggregate generating capacity of 1,000,000 kw., which is equivalent to about half the capacity of the output of turbo-generators contemplated from the new works in a year.

The men responsible for this new Russia have undertaken to build up an industrial system in a community overwhelmingly agricultural, and these turbo-generators to be produced at the Kharkov works will facilitate this end by providing the means for supplying power to hundreds of new works and factories. At the same time, it will assist in bringing about a wholesale revolution in agriculture by enabling the State and collective farms to be equipped for large-scale operations.

Whether these works will be on full production in the time allocated is difficult to say ; it has been claimed that 70 per cent. of the programme included in the Five Year Plan was completed in the first three years, and since 1932 completes the fourth year of the plan, the authors may achieve all that was originally desired ; in any case, they must be given credit for having brought into being, at war-time speed, a vast industrialised system. They have built new factories and equipped them with machinery on a scale that is a challenge to the more powerful industrial states. Whole towns have now sprung up where five years ago only villages or nothing but fields existed, and although efforts have been concentrated on the development of industry, the interests of the workers and their families have not been overlooked. Welfare services have been instituted in the great centres ; hospitals, clinics, maternity homes, club houses, and recreation grounds all form an important part in this great scheme.

Dnieper Power-Station Opened.

THE great hydro-electric power-station across the River Dnieper, forming part of the new construction of the Dnieper Combine, was formally opened on October 10 in the presence of high Soviet officials, delegations of workmen, and peasants from many parts of the U.S.S.R. Reference was made to this huge undertaking in an article published in our August issue. This hydro-electric power station was designed for a capacity of 800,000 h.p., and when completed will be the largest of its kind in the world.

The Dnieper power-station will provide the basis for the development of new industries ; actually, the Combine is creating a new metallurgical and industrial centre in the southern steppes of the Ukraine, in which this power-station is included, and a new town is being built. These have sprung up in a region where, until last year, there was practically no industry of any kind. The achievement is one of which the Russians are justifiably proud. The scheme is expected to be completed next year.

The Use of Town's Gas in the Melting and Heating of Metals

By J. C. WALKER.

Town's gas needs no storage facilities; it has constant quality and is always available. These factors enable heating operations to be effected with great precision, and accurate control can be maintained without the aid of specialised labour.

PROSPERITY is not conducive to hard and honest thinking. It takes a depression, when executives are not being overworked, to encourage really basic reorganisation. The wise manufacturer, instead of complaining of the unfairness of things, sits down and analyses all his processes and organisation in the most minute detail, cutting out superfluous parts here, simplifying and rearranging there, planning ahead so that, immediately confidence and, therefore, capital return to industry, he can scrap his obsolete plant and substitute modern plant and modern methods. The job is naturally not so easy as it sounds, and it must be admitted that up to the present the average American manufacturer has gone further into the matter of accurate analysis and costing than the average English manufacturer.

There is no better example to be taken than that of fuel. A little knowledge is a dangerous thing, and has so often led to the comparison of fuel costs solely on a basis of potential British thermal units per penny. A little more knowledge would have revealed the fact that different fuels alter various items of cost all through the manufacturing process, and a complete cost estimate of the whole process must be prepared for each fuel before the choice is made. The idea seems so simple as to be elementary, but it is astonishing how few manufacturers have really grasped it and put it into practice.

Some Factors that have Facilitated the Use of Town's Gas as an Industrial Fuel.

Years ago town's gas was employed primarily as an illuminant, and was manufactured to meet illuminating value standards. Then, for any but the smallest industrial applications, it was considered such an expensive fuel as to be out of the question. At the present time, however, the use of the illuminating value, as a measure of quality, has been practically abandoned and heating value has replaced it as a statutory standard. Many factors have contributed to this change, but probably the most important is the increasing use of town's gas for heating and industrial purposes. Improved manufacturing methods and a clearer understanding on the part of the manufacturer of the value of town's gas has had a considerable influence towards its greater application. With improvements and the adoption of the heating value standard, the price has been much reduced, and this in a measure has accounted for its rapid rise as an industrial fuel.

Under the heating value standard the unavoidable variation in quality due to the presence of condensable hydrocarbons has been eliminated with a resulting increase in uniformity of quality that is of great importance in all industrial applications.

Its origin, as well as its properties, is a fundamental reason for the importance of town's gas as a fuel in this country. Coal is our natural source of fuel, but its use in a raw state is not only unscientific but uneconomic for any but the largest applications. Carbonisation is at present the most thermally efficient method of up-grading coal, making available as it does over 80 per cent. of its heat value as gas, coke, and by-products. The carbonising industries are, therefore, performing a national service of great importance by utilising the country's coal resources in the most efficient manner.

Thermal Efficiency of Gas Cumbustion.

The very fact that other fuels have to be gasified before being burnt points to the reason for the thermal efficiency of gas as a fuel. Intimate mixture of fuel and oxygen is the essential condition for complete combustion, and the less the amount of excess air required to ensure this, the greater is the thermal efficiency of the process. Obviously then, an efficient fuel must be one that is as finely divided as possible. Hence the use of pulverised fuel, and the fact that oil is atomised before being burnt. Gas is in a finer state of subdivision than either of these and, consequently, burns more efficiently. Moreover, gas needs no pulverising or atomising plant, and is, therefore, much simpler and more reliable in use.

Gaseous fuels, being the most flexible, approach the ideal for industrial operations. Theoretically it is possible to mix the fuel and air in such proportions as to obtain perfect combustion—that is, to bring every particle of combustible material into contact with the proper amount of the supporter of combustion, and to have neither excess fuel nor excess air in the products of combustion. It is, however, extremely difficult to maintain an ideal fuel-air ratio and, in consequence, the process in which fuel is applied must determine which shall be in slight excess in the combustible mixture. Thus, in the melting or heating of metals, where a slightly reducing atmosphere is desirable in order to avoid oxidation of the charge, the combustible mixture should contain an excess of fuel.

Efficient Application of Heat.

Not only is the production of gas from coal a thermally efficient operation, but the production of heat from gas is also thermally very efficient. In contrast to this, while the production of heat from electricity is even more efficient, the production of electricity from coal has an efficiency of only about 20 per cent., so that the combined efficiency of the two operations is much higher with gas than with electricity. The next consideration is the application of the heat generated by combustion, and this is, perhaps, the most important point of all. Raw coal is so cheap that, even though its combustion is inefficient, the heat produced would still be cheap if it were possible to apply it accurately and effectively. In practice, however, this can only be done on a large scale in such things as power-station boiler-plant. For most other industrial purposes the effective application of heat is not so easy, and accurate temperature control and even atmosphere control become of the greatest importance. It is on these factors that the success of town's gas as an industrial fuel depends. A gas burner is such a simple device that its size and position can be varied almost indefinitely in order to apply heat to any desired spot. The amount of heat supplied is equally easy to control and can be regulated automatically by the simplest devices. In connection with temperature and atmosphere control a point which is not often made sufficiently clear is the importance of absolute constancy in the properties of the fuel. With gas the properties in question are calorific value, specific gravity, freedom from impurities, and pressure. In the case of town's gas the calorific value and purity are fixed by statute, and care is always taken to maintain specific gravity at a definite value. The advent of high-pressure feeders and governors

has also enabled pressures to be accurately maintained at all points. The great disadvantage of producer gas, as compared with town's gas, apart from the lower efficiency caused by its large content of inerts, is that its properties are very variable, and accurate temperature and atmosphere control is, therefore, impossible, while, unless expensive purifiers are installed, the large and variable content of tar and other impurities is apt to cause trouble, and in many cases makes direct firing impossible.

Application of Gas Enhanced by Accurate Costing.

Having considered the technical application of town's gas as a manufacturing fuel, the question of costing arises, and this is generally the deciding factor. Looking generally at the trend of industrial method, it is clear that everywhere inferior materials and simple haphazard methods are being replaced by more valuable materials more carefully and accurately handled by expensive machinery. This is the whole principle of mass production, and it should not be imagined that mass-produced articles are necessarily made of inferior materials and are of worse quality than goods made by old-fashioned methods.

Another important effect of the change in manufacturing methods is that the high capital cost and rapid obsolescence of manufacturing units has very much increased the importance of ensuring constant high throughput with a minimum of rejects in order to spread the capital costs over as many articles as possible. This constant high throughput can only be attained through elaborate attention to detail, accurate timing of each operation, and absolute reliability in all processes. It is, therefore, essential that heating operations of all kinds should be just as accurately controlled and reliable as mechanical operations. A high-grade fuel is for this reason an essential complement to modern mechanical methods. Its constant composition and the simplicity with which it can be controlled make town's gas an ideal fuel where the heating process is one of a series of interconnected operations, because automatic control is necessary, and its accuracy depends on the quality of the fuel, and its reliability on the simplicity of the controlling apparatus. A low grade fuel might cost less per heat unit, but would decrease the throughput of first-class articles, and, therefore, increase the capital cost and overheads chargeable to each. This factor is especially important where the value of the article is already high by the time it comes to be processed, and where there is a possibility of spoiling it at this stage. The use of a high-grade fuel will often, under these circumstances, save more than it costs by this reduction of spoilage alone.

In a similar way accurate temperature and atmosphere control, such as is possible with town's gas, often saves large quantities of valuable materials which would otherwise be wasted. A good example of this occurs in the tinplate industry, where recent experiments showed that the accurate temperature control obtainable with gas-fired tin pots so far reduced the variation in the thickness of the tin coating over the area of each sheet that about an ounce of tin was saved per box. The cost of firing was approximately twopence per box, whether it was done by gas or coal, and the value of the tin saved was about a penny. The cost of the operation was, therefore, halved.

Design of Heating Appliances Influence Type of Fuel.

The application of town's gas for industrial purposes has developed with the gradual improvement in the design of furnaces and with progress in burner construction. Broadly, suitable furnaces for the employment of this fuel are classified in the following types :—(*a*) Externally heated ; (*b*) natural-draught regenerator furnaces ; (*c*) low-pressure gas and air furnaces ; (*d*) low-pressure gas furnaces with air blast ; (*e*) high-pressure gas furnaces.

Low-pressure gas furnaces designed for the melting of lead, linotype metal, and other soft metals, are in considerable use, while, designed to act as a lead-hardening bath or as a salt bath, they fulfil efficiently very useful service. Special designs of these furnaces ensure a complete combustion with the flame reaching a high temperature, with a corresponding high duty per unit of gas consumed.

As long ago as 1911 Dr. E. W. Smith referred to the advantages of using town's gas for melting aluminium. In a paper delivered before the Institution of Gas Engineers he gave the statement, made by the manager of some aluminium works at which high-pressure gas had displaced coke for melting purposes. It was claimed that the labour costs were halved, the cost of melting more than halved, the amount of metal melted per pot was much increased, there was less oxidation of the metal during the melt owing to the presence of a reducing atmosphere throughout the furnaces, the method proved to be cleaner, heats were more easily controlled, and produced an alloy more regular in composition with improved physical properties.

At that time this was a comparatively new process, but remarkable development has been effected since ; town's gas is now being successfully used as a fuel for melting a wide range of non-ferrous metals and alloys.

The principle of recuperation applied to furnaces designed for use of town's gas has facilitated its use for carburising, reheating, hardening, annealing and normalising, billet-heating, etc. By this method the temperature of the flue gases is reduced, the heat being retained for use in the furnace, and not only is great economy of fuel effected, but it has made possible the attainment of temperatures formerly considered to be outside the economical scope of town's gas-fired furnaces, when used on a large scale.

Some Recent Gas Consumption Figures.

In order to give some idea of the probable gas consumption needed for various purposes under modern conditions, the following estimates, which have been prepared by Dr. Walter, of the Birmingham Industrial Research Laboratories, are appended. The calorific value of the gas referred to is 475 B.th.u.'s per cubic foot gross.

Carburising.—For continuous working at 900° to 920° C. a consumption of 1·6 cub. ft. per pound of gross load has been obtained, but 2·0 to 2·2 cub. ft. is a more usual figure. For intermittent working, where the load is allowed to cool down in the furnace after each soaking operation, the consumption would be about 5 or 6 cub. ft. with a soaking period of about ten hours.

Re-heating Ferrous and Non-ferrous Metals.—For re-heating, normalising, and annealing steel forgings, finished components and carburised work at 850° to 900° C., from 1·5 to 1·75 cub. ft. per pound is usual, though with continuous operation 1·2 cub. ft. is possible. For these purposes the accurate atmosphere control obtainable with town's gas is of great advantage. For annealing brass (600° to 700° C.) 0·6 to 0·7 cub. ft. per pound is usual except for pressings and spinnings, which require about 1·4 to 1·5 cub. ft. For annealing copper at 500° C. in water-sealed furnaces 1·0 to 1·2 cub. ft. is needed.

Metal Melting.—Typical figures for metal melting are :—Type metal (continuous)—700 cub. ft. per ton ; aluminium (open hearth furnace)—3 cub. ft. per pound ; brass (in crucibles)—5 cub. ft. per pound ; nickel—something over 10 cub. ft. per pound according to quantity melted.

Forging.—For intermittent forging operations with temperatures up to 1,400° C., 5 cub. ft. per pound is an average consumption. With larger forges working continuously this can be reduced to about a half, whilst, with very large billets, figures as low as 1·8 cub. ft. per pound have been obtained.

While the foregoing figures are accurate at the moment, the rapidity with which the industrial use of gas is increasing has encouraged research by gas undertakings and appliance makers to such an extent that efficiencies show a rapid rise as each new furnace comes on to the market.

The Measurement of the Surface Temperature of the Metal during the Drawing of Wire

By F. C. Thompson, D.Met., M.Sc., and H. G. Dyson, B.Sc.

A method of measuring the heat generated by metal when being drawn is discussed and some results are given which are consistent with results of other investigators.

ALTHOUGH some measurements have been made of the amount of heat which is generated when wire is being drawn (at relatively low speeds), no serious attempt appears ever to have been made to determine the actual temperature attained by the surface of the metal which is in contact with the die. This note is concerned mainly with a method by which this may be accomplished, but a few results are recorded and discussed.

The problem is one of some definite practical importance, since the maximum temperature reached during the drawing has, in some cases at any rate, a distinct influence upon the mechanical properties of the product. It has, for instance, been suggested that the increase of tensile strength of a steel wire drawn down in a few very drastic passes when compared with that of one reduced an equal amount but in a larger number of light draughts, may be due to the material in the former case being heated up, superficially at any rate, to the "blueing" temperature at which definite alterations in the mechanical properties are induced. It has even been suggested that in certain types of modern, high-speed, continuous drawing machines some non-ferrous metals may be heated to such a temperature that they are automatically annealed.

The matter is of interest also in connection with the material of which the die itself is made. It has been shown[1] that, in addition to the greater weight of wire which may be drawn before the die needs attention, the power necessary is much less, at times as much as 33%, when a sintered tungsten carbide die is substituted for one made of a high carbon steel. A limit is, however, placed upon the possibility of employing the former material, since it appears to be somewhat susceptible to flaking under thermal stresses if the surface temperature is allowed to rise unduly, in which case some form of water cooling may be required. Although the work to be recorded in this note was carried out on a steel die only, the method should be applicable to carbide dies as well.

The experimental proceedure adopted was as follows: To one corner of the die, insulated by ebonite from its supports, a copper lead was soldered. The wire to be drawn passed over an insulated copper contact strip (Fig. 1), to which a second lead was attached, and these leads were taken to a mirror galvanometer. To ensure a good contact with the wire, the contact strip had a slot cut in it, the wire pressing lightly upon it at both sides for a length of about a centimetre. A thermocouple was thus produced of which the wire-die interface was the hot junction, the cold junction being at the temperature of the room. The method is, therefore, essentially analogous to that of Herbert,[2] for the measurement of the temperature of the cutting edges of tools. Where the E.M.F. set up was too high for the mirror galvanometer, it was measured on a millivoltmeter by means of a change-over switch which was included in the circuit.

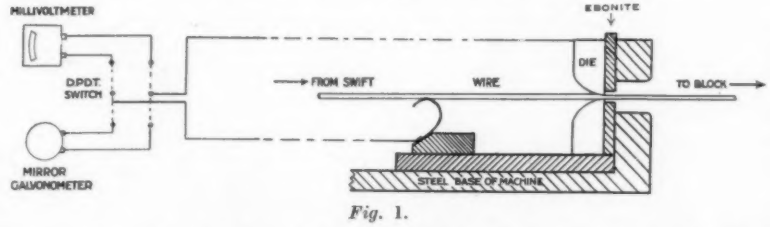


Fig. 1.

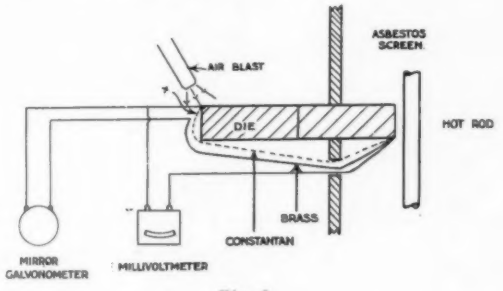


Fig. 2.

The calibration of the couple, which should clearly be done on the actual die itself, presented some difficulty.

TABLE I.

70 : 30 brass wire drawn from 0·071 in. to 0·0638 in.—*i.e.*, a reduction of area of 19·1% in a steel die of 6½° semi-angle.

	A.	B.	C.
Lubricant	None	Soft Soap	"Oil-dag"

A.		B.		C.	
Speed, Ft./Min.	Temp. Rise, ° C.	Speed, Ft./Min.	Temp. Rise, ° C.	Speed, Ft./Min.	Temp. Rise, ° C.
3·8	36·5	1·2	12·2	2·1	19
6·5	49·0	7·8	46	6·3	38
9·4	60·5	9·7	56	10·6	36·5
14·8	77·0	13·7	54	13·5	42
18·1	83·0	22·0	60	40·0	60
		37·2	67	49·0	71
		56·0	81		

A length of the wire to be drawn down, brass in this case, was soldered on to one corner of the draw-plate. From this, and from the opposite corner of the plate, copper leads were taken to the galvanometer. The steel-brass hot junction was then heated by radiation from a hot copper rod, a screen preventing the transference of heat directly to the cold junction. The temperature of the latter was still further maintained constant by an air-blast. The temperature difference of the hot and cold junctions was measured directly (Fig. 2) by a differential copper-constantan couple. The junction X was held in contact with the cold junction connection of the die, from which, however, it was insulated by a thin piece of asbestos paper. All the other connections, except those to the measuring instruments, were soldered. By noting the deflection of the galvanometer (or millivoltmeter) and the temperature difference of the brass-steel thermocouple as determined by the copper-constantan couple, calibration of the former could be effected. This calibration curve is shown in Fig. 3.

1 Thompson and Francis. "Carnegie Scholarship Memoirs." Iron and Steel Institute 1931. Vol. XX. p. 87.
2 Herbert Proc. Inst. Mech. Eng. 1926. i., 289.

The drawing of the wire was done on a hand-operated machine, the speed of drawing being maintained as constant as possible. When this constant speed had been attained, the wire was marked, a stop-watch started, and the maximum reading of the galvanometer, which was quite reasonably steady, taken. The wire was then marked as before, just as the time was again noted. From the time readings and the distance between the marks on the wire, the speed of drawing was obtained.

Three series of measurements were made on this brass wire, chosen because it gives a high E.M.F. with the steel die, one using no lubricant, one with "oil-dag," and one in which the lubricant was a potassium nut-oil soap. The results are given in Table I. and plotted in Fig. 4.

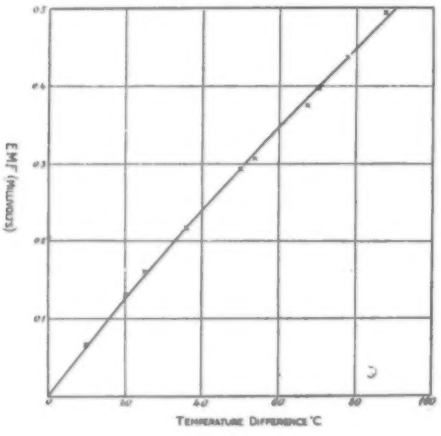


Fig. 3.

The influence of no, or of an unsuitable, lubrication in increasing the temperature attained at the surface will be at once apparent. This temperature is distinctly greater at a speed of only 16 ft. per min. for the unlubricated die than it is at 50 ft. per min. when "oil-dag" was used. The soft soap occupies an intermediate position. This is not surprising, since in all the work which has so far been carried out hard soaps are better lubricants than soft ones provided that a continuous film of the lubricant is obtained

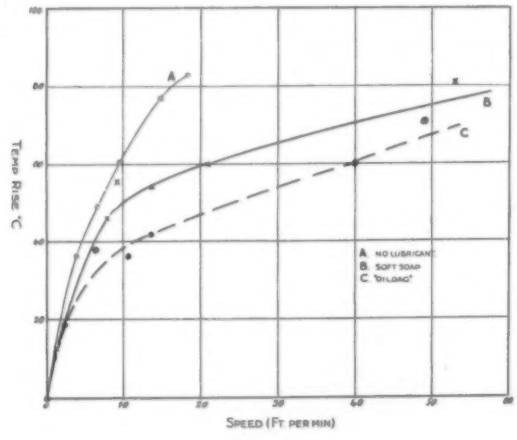


Fig. 4.

on the surface of the wire. This is not always an easy matter, and where the best possible conditions are required hand lubrication has always been used. The advantages offered by many liquid and greasy lubricants appear to lie as much in the ease with which this continuous film may be obtained as in any inherently good lubricating qualities. It is probably true that this ability to adhere to the surface of the wire is, in practice, of more importance than are small differences in the real lubricating properties of the various media.

It will be observed that in each curve there is an initial period of rapidly rising temperature as the speed is increased, and a later one in which the temperature rises steadily and more slowly. It is highly probable that a final stage of greatly enhanced heating exists, but conclusive evidence has been obtained in other directions that, with normal lubrication, this will occur only at speeds which are far in excess of anything which has been attained in the present work.

It will be well now to inquire to what extent the order of the results here recorded are in agreement with those of other work. Pomp, Siebel, and Houdremont[3] have proposed the formula—

$$\Delta t = \frac{P}{f^1} \cdot \frac{1}{A \cdot c \cdot \gamma},$$

where Δt is the *mean* rise of temperature of the wire ; P is the tension in kgms. : f^1 is the area of cross-section in sq. cms. of the drawn wire ; A the mechanical equivalent of heat in cm. kgms. per kilocalory—*i.e.*, 42,700 ; γ is the density of the material in kgms. per cc. : and c the specific heat in kilocalories per kgm. per ° C. For mild steel this reduces to—

$$\Delta t = 0{\cdot}026 \frac{P}{f^1}.$$

Using a steel die of 6° semi-angle and a speed of 76 ft. per min., those authors have obtained the following results :—

Reduction of Area %	Mean Rise of Temperature in °C.
10·0	27·0
17·2	53·7
23·6	60·5
36·1	61·9
41·0	71·5

For a reduction of 20% a rise of temperature of about 55° C. would be expected, but this calculation assumes that the whole of the work done is converted into heat, which is clearly incorrect. Giraud[4] has shown that about one-third of the work done at low speeds of drawing is so converted. Taylor and Farren,[5] as a result of measurements on metals stressed in pure tension, conclude that for a steel some 8–13% of the work thus done is represented by an increase in the internal energy of the metal. That this should be less for pure tension than for drawn wire is to be expected, since the increase in the tensile strength which can be effected by drawing is far greater than that which it appears can be induced by a tensile stress. Reverting to the figures given by Pomp, Siebel, and Houdremont, and by Giraud, it would appear that for a 20% reduction of area a mean rise of temperature of the order of 20–30° C. would be expected. Now since this heat is generated to a greater extent at the surface, where friction is operative, than elsewhere, one would expect that the temperature measured in the present work would be appreciably higher than that calculated for the wire as a whole. At a speed of 50 ft. per min., and with the best lubrication provided in the present tests, roughly that which would be industrially practicable, the increase of the surface temperature for a reduction of area of 20% is of the order of 60° C. This may be regarded then as being in reasonable agreement with the foregoing estimate. On the assumption that 10% of the total work done, using a steel die, is the result of surface friction, Weiss[6] has calculated that for a copper wire drawn down from 6·5–2·53 mms.—*i.e.*, 74%,—the mean rise of temperature is 43° C., a result which again is consistent with the order of the effect which we have obtained.

3 Pomp, Siebel and Houdremont, *Mitt. K.W. Inst. f. Eisenforschung* IX., Lief. iv, 1929, 53.
4 Giraud, *Revue de Met.* April, 1928.
5 Taylor and Farren. Proc. Roy. Soc. A., 107, 422.
6 Weiss, *Zeit. f. Metallkunde*, XIV. 1922. 170.

The International Foundry Conference

Collaboration in overcoming foundry problems at Paris.

THE fourth World Foundry Conference, which was held in Paris from September 13 to 18, was organised by the Association Technique de Fonderie of France, and was under the presidency of M. Eugène Ronceray, the president of the Association. Included in the 600 delegates and ladies attending the Conference, and the functions organised in connection with it, were some 35 representatives of Great Britain. The Conference was of more than usual interest to British foundrymen, as Mr. Andrew Harley, of the Daimler Co., Coventry, a past president of the Institute of British Foundrymen, is this year president of the International Committee of Foundry Technical Associations, the body which regulates the arrangements in connection with international foundry conferences and other matters of interest to the various member societies. Mr. Harley was the principal speaker and guest at many of the functions. The party of British foundrymen, organised by the Institute of British Foundrymen, included Messrs. F. J. Cook, V. C. Faulkner, and J. Cameron, past presidents, and T. Makemson, general secretary and secretary of the International Committee. The Institute of Metals was represented by its president, Sir Henry Fowler, and Mr. J. G. Pearce, director of the British Cast Iron Research Association, represented the Iron and Steel Institute.

The opening meeting of the Conference took place at the Sorbonne on September 14 under the presidency of the Under-Secretary of State for Technical Education. Following speeches by M. Ronceray, Mr. Harley, and representatives of the Committee of Organisation, the meeting discussed a comprehensive paper by M. Ageron on the "Prevention of Accidents in the Foundry." The remainder of the morning was devoted to a lecture by M. Bloch, illustrated by cinematograph films, on the organisation of the workshops of the Paris-Orleans Railway Co. This film was of a very informative character, and gave considerable information regarding the scheme of organisation in these well-known railway shops. After luncheon at the Hotel Lutetia the members of the Congress paid an official visit to the International Foundry Exhibition.

After the opening day of the Conference a very full and complete programme was arranged for the members. The mornings were devoted to visits to works or to the Exhibition, and the afternoons to the presentation and discussion of papers. As nearly 40 papers were presented dealing with almost every aspect of foundry practice—technical, manufacturing, and administrative, it was necessary to duplicate sessions, each dealing with groups of papers on some kindred subject. Most of the papers were presented in the conference halls of the Ecoles d'Arts et Métiers. Additionally, there was a joint meeting with the Society of Civil Engineers of France, held in the building of this Society. An interesting and valuable innovation was the organisation of a number of conferences, which were held on the stand of the Paris Foundry High School at the Exhibition. The subjects at these conferences which were introduced by recognised authorities included the melting of steel in the cupola; new methods of rapid analysis; and the testing of moulding sands. Such conferences permit of more informal and detailed consideration than is generally possible in the discussion of written and carefully prepared papers, and the arrangement may well be commended to the notice of other technical organisations.

The official exchange paper of the Institute of British Foundrymen was presented by Professor Hanson, of Birmingham University, who took as his subject "Some Causes of Defects in Aluminium Alloys."

Professor Hanson's paper was a comprehensive study of the absorption of gas by aluminium alloys, and the effects of gas absorption on the casting. Treatment of the metal before casting, and careful control of the conditions of melting and casting, were recommended to reduce the defects due to gas absorption.

The official exchange paper of the American Foundrymen's Association, the authors of which were Messrs. H. J. Roe and E. M. Gingerick, also dealt with the methods of promoting soundness in aluminium castings. The causes of porosity were considered in detail, and recommended precautions for promoting soundness included the employment of the lowest possible melting and casting temperatures: careful choice and control of suitable melting plant, and careful attention to the moulding methods, particularly with a view to obtaining a correct and uniform speed of solidification of the metal in the mould.

These papers were presented at a special session on aluminium and its alloys. Another interesting paper in the same session was that of M. Sonnino, presented on behalf of the Italian founders. This paper discussed the relative advantages of electric and fuel-fired furnaces for melting aluminium, and concluded that the economy of the fuel-fired furnace was largely offset by the technical advantages of the electric furnace, such as easy regulation of temperature, inert atmosphere, easy removal of the gases, and low melting loss.

A special session devoted to the study of irons included several papers of a technical character, dealing with the influence of molybdenum and titanium, and also the influence of high-silicon content on graphitisation. Papers dealing with oxygen in iron and irons of very low carbon content were also presented.

Several important papers were presented at the session on bronze and other copper alloys. Of particular interest was a paper by Dr. Laissus on metallic cementation, in which he showed that the process of cementation can be applied not only to the absorption of carbon in steel, but to the absorption of a number of other elements such as chromium, molybdenum, tungsten, and zinc. Examples were given of the applications of the process to decorative work and to protective coatings.

A further session was devoted to the consideration of six papers on malleable cast-iron and steel.

A series of papers on testing included an interesting résumé on testing by the Scientific Committee of the Belgian Foundrymen's Association, and a résumé of methods of testing machinability by M. Henon. A study of the desulphurisation of iron by sodium carbonate, and a report by Mr. J. M. Espana on the progress made in the preparation of an international dictionary of foundry terms were also included in this group of papers.

Two miscellaneous sessions gave an opportunity of discussing a number of papers dealing with practical foundry work; Mr. J. Varley, of Liége, presented a valuable paper co-ordinating his observations on the causes and prevention of expansion of moulds and cores. Another interesting practical paper dealt with special cores; the author, M. Fabre, describing in considerable detail the

processes of making cores in loam, in skeleton core-boxes, and by other non-standard methods. M. Simorre presented an exceptionally comprehensive paper dealing with the production of a large 7-ton vat made in acid-resisting iron. The whole process including the patternmaking, moulding, coremaking, and preparation of the metal were dealt with in detail, and the times occupied in each operation were also given. This was one of the most comprehensive and useful practical foundry papers that has been presented for some time.

The special joint meeting of the Conference and the Society of Civil Engineers of France was held under the joint presidency of Professor Portevin, president of the latter body, and M. Ronceray. At this meeting an important paper by M. Guillot, director of the Ecole Centrale, and Dr. Ballay was presented, and gave a comprehensive review of alloy cast irons. The effects of chromium, nickel, molybdenum, and aluminium were considered, with particular reference to the properties of corrosion resistance, resistance to high temperatures, and the electrical properties. At the same meeting M. R. Lemoine presented a paper on "The Application of the Acid Electric Furnace in the Steel Foundry."

Works Visits.

The works visited included two modern automobile foundries, namely, those of the Renault concern and the Citroën foundries.

The most spectacular portion of the Citroën foundries is the section devoted to the manufacture of cylinder blocks. The moulds are formed entirely of oil-sand cores, and these, together with the cores for the interior of the castings, are made in a core shop operated mainly by female labour. Most of the cores are made on machines of the press type in metal core boxes, and are conveyed to the drying stoves on special racks. An interesting feature is the care which is taken to rectify distortion of the cores during drying. Certain types of cores for example are placed in the jig, which automatically passes over a grinding wheel which removes excrescences and produces a perfectly true surface.

The moulding boxes which contain the mould assembly are rammed on moulding machines, which are arranged in groups of four on a turntable. A box is rammed by a sand-slinger machine, the turntable then rotates, removing this box from the sand slinger, and bringing another machine and box into place. The box previously rammed is levelled and removed from the machine, and another box is put in position before the machine again passes under the sand slinger. The rammed flasks are placed on a conveyer, and men standing at suitable intervals along the conveyers insert the cores in position until the finished mould, suitably weighted and provided with pouring bush, is cast at a point adjacent to the cupolas. The cast mould then passes down the reverse side of the conveyer through a cooling hood to the shakeout grids, the sand falling through the grids and passing to the sand-preparing department, and the castings pass on to the cleaning shop. The boxes are returned to the moulding machines for further use. Conveyers are used in this foundry for almost every problem of transport.

The Renault foundries cover an area of 45,000 square metres; they include a steel foundry with four converters and an electric furnace in course of construction. The cylinder foundry has a capacity of 40 tons of iron castings per day; there is also another iron foundry for the manufacture of miscellaneous pieces with a capacity of 60 tons per day. Other foundries in the Renault works include a malleable foundry for the production of black-heart malleable castings, and aluminium, bronze, and die-casting foundries.

Other foundries which were visited during the Conference included the Usines de Vitry, which manufactures general steel castings by the converter process; the foundry of Bonvillain and Ronceray; and the Lobstein foundry at Argenteuil. The bronze and aluminium foundries of the Companie des Compteurs were also visited.

Functions.

The social functions in connection with the Congress include a reception at the Hotel de Ville, a reception by the Secretary of State for Technical Education at the Ecole des Arts et Métiers, a dinner-dance at the Eiffel Tower, and a banquet at the Hotel Palais d'Orsay, under the presidency of the Under-Secretary of State for Technical Education. The various foreign consulates, government departments, army and navy, together with a large number of French and foreign technical organisations, were represented at this banquet, and the president of the Association Technique de Fonderie, M. E. Ronceray, took the opportunity of thanking all those who had assisted in the organisation of the congress.

The principal speech on behalf of the visitors was made by Mr. Harley, president of the International Committee of Foundry Technical Associations. Mr. Harley expressed the thanks of the visitors for the way they had been entertained, and pointed out the value which would accrue to the foundry industry from the papers which had been presented, from the works visitors had been able to visit, and the comprehensive exhibition which had been organised.

International Foundry Exhibition.

The International Foundry Exhibition was held at the Parc des Expositions, and was organised mainly by the Syndicat Générale des Fondeurs de France. The Exhibition was opened on September 3, and continued until the end of the Conference period on September 18.

The present state of world trade had undoubtedly had its effect upon prospective exhibitors, and there were not so many stands as at some of the previous exhibitions held in Paris; the standard of the Exhibition, however, was very good. Although there was very little that was entirely new there was much that was of interest, and many recent developments in foundry plant such as rotary furnaces, core-blowing machines, and sand-preparation plant were adequately treated.

Several stands were organised on a co-operative basis by a number of firms who are members of various local groups of founders, or by a number of firms from a foreign country who had combined in a joint exhibit. The largest and most spectacular stand in the exhibition was a co-operative stand organised by some 27 Italian firms. This stand included large steel castings from the Vanzetti and Fiat foundries, aluminium castings from the Societa Italiana dell' Aluminio, and small typewriter castings from the fonderia Olivetti, the whole forming a very impressive exhibit of the very high standard to which foundry practice has been raised in modern Italy.

Similar co-operative exhibits were shown by the founders of Belgium and Spain. Among the various German firms represented was the Vereinigte Stahlwerke. The numerous French foundries whose products were shown, either individually or co-operatively, put forward a comprehensive selection of castings of all descriptions from large gas-engine bed-plates to small die castings. Steel and malleable castings were also shown, and exhibited the high degree of efficiency which has been attained in these branches of the industry in France.

A considerable section was occupied by educational and research institutions, notable among whom were the Ecole Superieure de Fonderie, and the various Ecoles d'Arts et Metiers. The exhibits consisted of apparatus, diagrams illustrating the programmes of work, specimens of text-books, students' notes, and samples of practical work in moulding, core-making, and pattern-making. The well-known Foundry Institute of Aix la Chapelle was represented in this section, and the British Cast Iron Research Association exhibited its sand-testing apparatus, diagrams, and samples of its publications. The technical schools in Great Britain were represented by the Constantine Technical College, Middlesbrough; the Sir John Cass Technical Institute, London; and the Keighley Technical College, Keighley. The last named showed a number of patterns of very creditable workmanship made by the students.

KANTHAL

A New Electrical Resistance Alloy

By J. H. Russell,

Works Manager, Hall and Pickles, Ltd.

This metallic material, an alloy consisting of aluminium, chromium and cobalt, has a high specific resistance and a low specific gravity. It withstands high temperatures and gives long service.

THE increasing application of electrical energy as a source of heat for domestic and industrial purposes has led to considerable research in the development of suitable resistance materials, particularly for high-temperature service. Investigation has been made on both metallic and non-metallic materials; much work, for instance, has been done on the nickel-chromium and nickel-chromium-iron alloys, and on refractory non-metallic materials like silicon carbide. Nickel-chromium alloys have been developed capable of withstanding temperatures up to 1,150° C., although generally their economical useful life is limited to about 1,050° C.

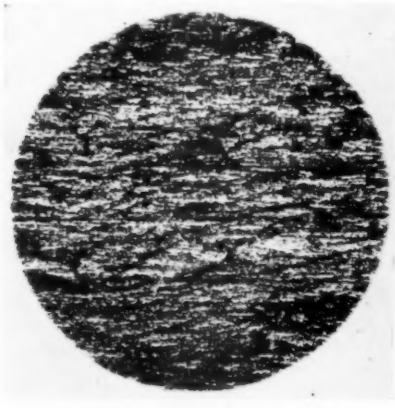


Fig. 1.—Kanthal A 1 strip × 95.

The need for resistances capable of withstanding higher temperatures was responsible for the development of non-metallic materials, and considerable success has been obtained by thoroughly mixing silicon carbide, silicon, and carbon together, pressing them into forms and then exposing them to the action of carbon monoxide at a temperature of about 1,500° C. These resistances possess high refractory qualities, great resistance to the influences of the atmosphere, and high variable specific resistance. They have been used with success for temperatures up to about 1,400° C.

The fabricating advantages of metallic materials are favourable to their use, but their lower temperature limit has been a drawback. On the other hand, the brittle character of non-metallic materials and the need for special care in the choice, and fixing, of contact ends has presented difficulties. Furthermore, their limited length and shape has limited furnace design. In spite of these disadvantages however, their resistance to temperatures of 1,400° C., has enabled them to cover a wide field of usefulness.

Recently, however, a new metallic resistance material, has been developed, known as Kanthal, in which aluminium, chromium, and cobalt are alloyed. One grade of Kanthal is capable of withstanding temperatures up to 1,325° C. for long periods, and is without the usual disadvantages generally associated with non-metallic materials. Kanthal alloys have a higher specific resistance, and lower specific gravity, than nickel-chromium alloys, and in the presence of sulphur are attacked to only a very small degree.

Kanthal is produced in three grades, and the permissible temperatures of heating elements made from them are as follows:—

Kanthal A1	maximum	1,325° C.
Kanthal A	,,	1,250° C.
Kanthal D	,,	1,050° C.

These maximum temperatures may be considered to be very conservative—for instance, Kanthal D has a much better life at 1,150° C., than 80/20% nickel-chromium (Graph Fig. 2).

The highest quality, a micrograph of which is shown in Fig. 1, may be used for heating purposes without protective gases at higher temperatures than any known base-metal alloy. It is produced in strip and castings. The second quality is produced primarily as wire, but also in castings and pyrometer sheaths. These pyrometer sheaths are hot rolled tubes, with comparatively thin walls, and not castings. The third quality is produced in both wire strip and castings, and is being used for many purposes for which 80–20 nickel-chromium is used.

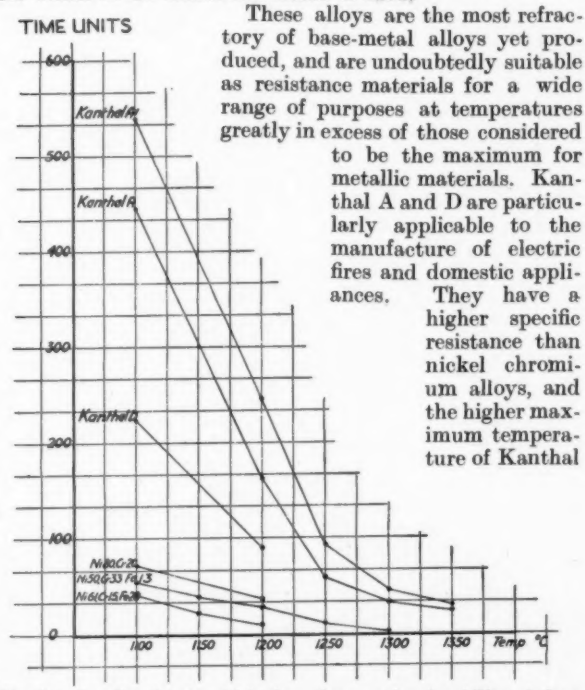


Fig. 2.—Results of tests which show the superior durability of these alloys.

These alloys are the most refractory of base-metal alloys yet produced, and are undoubtedly suitable as resistance materials for a wide range of purposes at temperatures greatly in excess of those considered to be the maximum for metallic materials. Kanthal A and D are particularly applicable to the manufacture of electric fires and domestic appliances. They have a higher specific resistance than nickel chromium alloys, and the higher maximum temperature of Kanthal A is advantageous. For reflector fires, the brighter optical effect is very pleasing.

Kanthal alloys have remarkable oxidation-resisting qualities, and have a very high specific resistance. The scaling temperature of the best quality alloy is above 1,350° C., and its specific resistance, at working temperatures, is about 160 microhms per cm.[3] The melting point is about 1,660° C. The resistance to sulphur of these alloys may be judged in comparison with two kinds of nickel-chromium alloys from the results of two tests given in the following tables:—

SULPHURETTED HYDROGEN TEST.

Alloy.	Increase of Weight in Grammes per Sq. M. per Hour.	
	650° C.	800° C.
Kanthal A	1·2	31·5
Ni 50, Cr 33, Fe 13	56·0	244·0
Ni 80, Cr 20	92·0	1182·0

SULPHUROUS ACID TEST.

Alloy.	Increase of Weight in Grammes per Sq. M. per Hour.				
	650° C.	800° C.	950° C.	1100 °C.	1250° C.
Kanthal A	0·8	0·0	1·8	1·9	6·8
Ni 50, Cr 33, Fe 13	3·7	2·0	11·4	12·5	506·0
Ni 80, Cr 20.....	105·0	2·8	9·0	9·9	135·0

The durability of a resistance material is dependent on the conditions under which it is used, and can only be accurately ascertained by use under normal working conditions. Bash and Harsch,[1] recommend a quick method of classification, which gives results that very closely approximate to those obtained in practical use. This test is used during the regular manufacturing operations in the production of Kanthal. Test results of Kanthal alloys, and three nickel-chromium alloys, showing the effect of the temperature on the durability of resistance wire are given in the graph, Fig. 2.

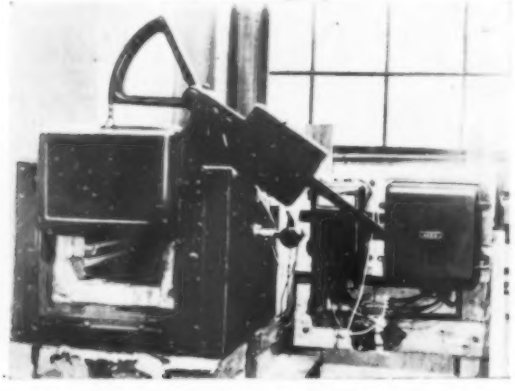


Fig. 4.—Furnace fitted with Kanthal A 1 elements for operating at a temperature of 1,325° C.

The electrical specific resistance of the alloys at 20° C. is

Kanthal A 1	145	michroms per cm³
Kanthal A	135	,, ,, ,,
Kanthal D	130	,, ,, ,,

The temperature coefficient is very regular, as shown in Fig. 3. It is necessary, when selecting material, to give due consideration to this resistance increase, which is smaller for heavy than for light sections.

Elements made from these alloys have already been used successfully in furnaces for hardening high-speed steel, glass melting, heat-treating of stainless steel, case-hardening, enamelling, pottery, sintering tungsten carbide, etc.

For instance, in Fig. 4, is shown an electric furnace, for operating at temperatures up to about 1,325° C. The elements are 20 × 2 mm. in Kanthal A 1 strip. The furnace rating is 8 kw. at 37 volts and 6 kw. at 32 volts. As the electrical specific resistance of this alloy, after a period of activity, is increased up to about 10%, the transformer associated with this furnace has a third tapping for 40 volts, and consequently the efficiency can be kept at the same value. The hearth-plate, it is of interest to note, is cast from Kanthal material.

[1] F. E. Bash and J. W. Harsch: "Durability of nickel-chrome resistor materials," Congres international pour L'essai des materiaux, Amsterdam 1928 p. 463.

In the manufacture of elements from these materials some very simple precautions must be taken. These are necessary because, at air temperature, the alloys are rather brittle, although they be tough and plastic when heated.

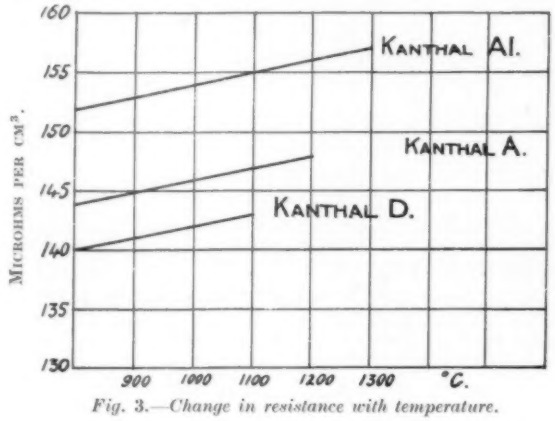


Fig. 3.—Change in resistance with temperature.

This brittle tendency is more pronounced with the heavier dimensioned materials than in wire or strip. Wire of a thinner diameter than about 1 to 1·5 mm., and strip with a thickness of about 1 mm., are as delivered

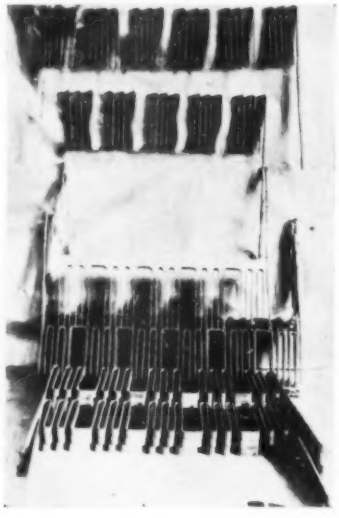


Fig. 5.—Kanthal A 1 elements prepared for furnace to be used for heat-treating stainless steel.

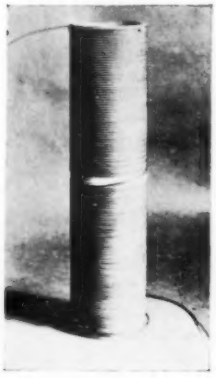


Fig. 6.—Element used in furnace for sintering tungsten carbide.

from the manufacturers, as plastic and tough as soft iron wire, but after a fairly long time of heating at high temperatures alloys tend to become rather brittle, utmost care must be taken in removing elements from a furnace after use, otherwise fractures will occur.

When coiling the larger sizes of wire, especially over 1.5 m.m. diameter, or bending strip above 1 mm. thick, Kanthal should be heated. A method recommended is to draw the wire slowly through the flame of a soldering lamp, or through small furnace, or by passing an electric current through it, and coiling while hot. In the same manner, the part of a strip which is to be bent can be locally heated with a soldering lamp. Strip or wire should not be bent or coiled round a bending radius less than three or four times the thickness of the strip or diameter of the wire.

These alloys are readily manipulated to conform to various shapes, as is indicated by Figs. 5 and 6. The former illustrates a set of elements manufactured from Kanthal A.1. strip, 30 × 2·5 mm., designed for an 88 kw. furnace operating at 1,100° C. for heating stainless steel. The

elements hang on the furnace walls, and it is of interest to note that the vertical length of the hanging band is 257 mm. Fig. 7 illustrates the application of Kanthal to elements for domestic purposes.

A further indication of the fabrication and the adaptability of this material is shown in Fig. 8, which illustrates elements for a 24-kw. glass-melting furnace operating at 1,100°–1,200° C. The strip is 25 mm. × 2 mm. Kanthal A1, and the voltage used is 40.5, which can be increased to 44.5 to overcome the increase in resistance after considerable use.

As with other resistance alloys, Kanthal will become soft at high temperature, and this must be kept in mind

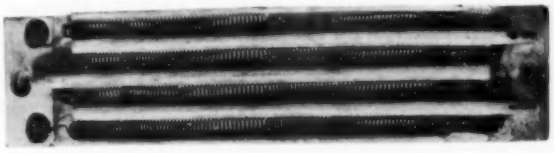


Fig. 7.—Kanthal as domestic fire elements.

when designing the elements and deciding on the method of mounting. It is important that they should be well supported, and not freely suspended at too great a length.

The effective superficial area of a Kanthal element in the interior of a furnace should not be provided with welds. On the other hand, it is frequently desirable to strengthen parts of the elements which pass through the wall of the furnace, in order to reduce the resistance and temperature at these points. The welding method recommended is by carbon arc. The element and thickening strips should be closely clamped together, and the and the edges melted by an arc produced between a carbon electrode, which is pointed, as the negative pole, and the element as the positive pole.

Direct current is used, and, when welding strips of heavy dimension, with a thickness of 2 to 3 mm., the tension ought to be about 30 volts, but this should not be exceeded. With thinner dimensions of strips the tension should be lowered

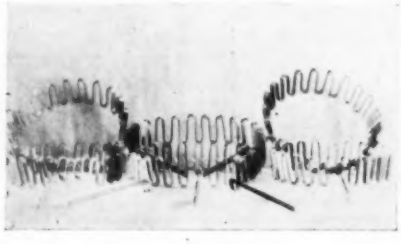


Fig. 8.—Kanthal A1 elements for glass melting furnace operating at 1,100-1,200° C.

to about 10–20 volts. Flux is not necessary, and should not be used. The parts of the strips which are to be welded ought to be heated to 600°–800° before welding, and allowed to cool very slowly after welding. The carbon electrode should be moved rather quickly along the edges of the strips, at a speed of about ½ to 1 m. per min., and it is an advantage for it to be steered by a ruler. The point of the carbon should be moved at a distance of 3 to 5 mm. from the strip, and it is necessary to note that a completed welding is somewhat more brittle than the remaining part of the strip.

In determining the dimensions of resistance elements, the design of the furnace, kind of current available, voltage, etc., are important factors, and must be considered. Generally the higher the temperature at which the furnace is to work, the heavier the material of the resistance elements should be, in order to avoid their deformation, which may lead to ruptures and short-circuit. On the other hand, the resistance material should not be so heavy as to involve the risk of overheating and even the melting of the core. On these grounds strip is preferable to wire for higher furnace temperatures than 1,150° C. Resistances of spiralled wire possess the advantage of being easier to handle, and can be replaced with greater ease. They can be conducted through a furnace wall with smaller loss of efficiency and less risk of local overheating.

There can be no doubt that the development of these alloys will have a considerable influence on the application of metallic resistances to furnaces for operation at higher temperatures than has been possible previously with base-metal alloys. Also, due to the many advantages apart from increased service, to the manufacture of domestic appliances. Every care is taken in their manufacture, and they may be relied upon to give efficient service over a wide range of temperatures.

The Education of Foundrymen.

At the opening meeting of the Lancashire branch of the Institute of British Foundrymen, Mr. S. P. Howden, M.Sc., Principal of the Openshaw Junior Technical School, gave an interesting address on "Why Educate the Foundryman." He emphasised the high degree of skill necessary to be able to supply intricate castings in different metals and alloys now demanded, and asserted that this skill would be acquired more easily if foundry-men were trained in fundamental principles that could be applied in practice. Much time is expended by efficient craftsmen in determining suitable methods to overcome difficulties that would be readily solved by a knowledge of first principles.

Mr. Howden has taken considerable interest in the Institute's educational work, and in appreciation of his efforts the meeting was held at the technical school with which he is associated. The large attendance of members demonstrated their gratitude for work done. The arrangements made at this school for the training students have been extended to prepare students for the certificate of the City and Guilds of London Institute in foundry practice and science, and the school was thrown open to those attending the meeting for inspection. Excellent facilities are afforded for this work, and although the instruction given is primarily for evening students, the suggestion was made that with sufficient students a part-time day course could be instituted. The course of study in its present form involves three years, at the termination of which students will be expected to present themselves for the City and Guilds certificate.

These classes, and others that are functioning successfully in different parts of the country, will do much to raise the status of foundrymen and lift them to a position commensurate with the high degree of skill proficient foundrymen possess.

Personal.

Mr. C. A. Bishop has relinquished the appointment of general manager of Davy Brothers, Ltd., Sheffield, and is taking up the appointment of the Company's London representative.

Mr. W. A. Sycamore, who has held the position of sales manager with A. G. Mumford, Ltd., and later their associated company, John Kirkaldy, Ltd., has joined the sales organisation of Davey, Paxman and Co. (Colchester), Ltd., and will be attached to their head office and works at Colchester.

Mr. R. J. MacFarlare, who was for some time associated with Messrs. Alfred Herbert Ltd. in Scotland, has joined the staff of B.S.A. Tools Ltd.

Sheet Annealing Furnaces, Past and Present.

(*Continued from page* 180.)

then lay them down again, returning below the hearth level to the starting position. There are also furnaces in which both sets of beams move, so that the sheet is conveyed through the furnace without stopping and without vertical movement. Due to the level surface of the beams, the sheets are easily kept flat, even in the case of very thin and small tin plates. Since the walking beams are always in the furnace and retain their heat, while at the same time requiring no water cooling, the fuel consumption is very favourable. The possibility of heating both above and below gives very uniform treatment and quicker throughput. For a given capacity the walking beam furnace can be made shorter than one with a roller hearth.

Metallographical Microscopy by means of Polarised Light

THE foundations of the study of optical anistropy in opaque substances were laid by J. Koenigsberger[1]. L. C. Glaser[2], K. Endell, and H. Hanemann[3] have applied these studies to metallography, and investigations of non-ferrous alloys by means of polarised light have been described recently in this journal by H. von Schwarz[4].

Clearly the method is a promising one for obtaining information about the anisotropy, orientation, and state of tension of the crystallites of the metal. A practical difficulty lies in the fact that vertical incidence of light is necessary, and this is not readily obtained when large magnifications are desired.

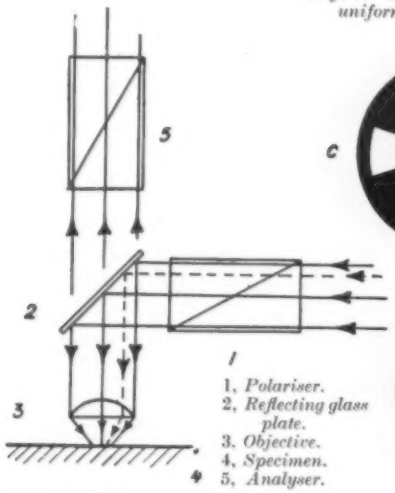


Fig. 1.—Path of rays in polarisation microscope with vertical illuminator.

Fig. 2.—Epiphragm for obtaining uniform angle of incidence.

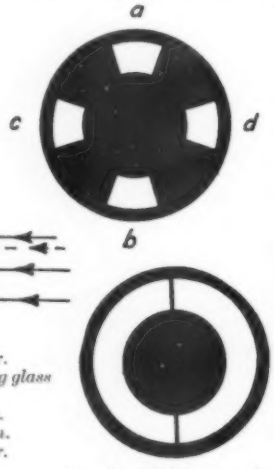


Fig. 3.—Epiphragm for obtaining uniform angle of incidence and azimuth.

1 *Zentr. Min.*, 1908, 365, 597; 1909, 245; 1910, 712.
2 *Z. techn. Physik.* 1924, 5, 253.
3 *Z. anorg. Chem.*, 1913, 83, 267.
4 METALLURGIA, 1931, 4, 180.
5 *Z. techn. Physik.*, 1932, 9, 408–10.

This difficulty is made evident by Fig. 1, which shows the path of the light rays in the ordinary polarisation microscope with vertical illuminator (a thin, reflecting glass plate). The angle of incidence of the linearly polarised light on the specimen is not uniform, but varies continuously from the middle, where it is truly vertical, to the edge, where the maximum deviation occurs. It is well known, however, that the effects produced by metals on polarised light depend on the angle of incidence.

To overcome this objection, L. Tronstad[5] has devised an epiphragm (shown in Fig. 2) which can be fitted directly after the condenser lens. This cuts out all the light except that passing through the annular space, thereby ensuring a uniform angle of incidence.

It is also desirable to control the azimuth of the linearly polarised light with respect to the plane of incidence. Isotropic metals cause no alteration in polarised light, of which the azimuth is perpendicular or parallel to the plane incidence (maximal darkness in the analyser), but when the angle is about 45° the linearly polarised light is transformed into elliptically polarised light and passes partly through the analyser. The epiphragm illustrated in Fig. 2 allows all possible azimuths, and it is necessary to make this factor uniform in addition to a uniform angle of incidence.

Uniformity of both is secured by using the epiphragm illustrated in Fig. 3. This can be rotated in relation to the polariser; thus, the light passing through the openings *a* and *b* can be made to vibrate in the plane of incidence, and the light passing through *c* and *d* at right angles to that plane; when the epiphragm is turned through an angle of 45° a brightening is seen on isotropic metals with crossed Nicols.

It will readily be seen that the apparatus is particularly advantageous at high magnifications; for, when the magnification is low, the aperture of the objective is small, and the incident linearly polarised light will approximate to the vertical even without the epiphragm. The dimensions must be chosen to suit the particular needs of the case, but, in general, a narrower opening gives a sharper and more uniform effect; a limit is imposed by the reduced intensity of light, which may render photography difficult.

Refractories Manual

THIS publication embraces, in a convenient form, standard specifications of the American Society for Testing Materials, methods of test, and definitions pertaining to refractories. It also includes the latest revision of the manual for interpretation of refractory-test data, which differs from the previous edition, published in 1929, in that more attention has been paid to the rational grouping of data, so that tests can be applied for lack of control.

The standardisation of test methods for refractories has been in progress for some time, and in this issue specifications are given for clay fire-brick for malleable furnaces, stationary-boiler service, and marine-boiler service. Methods of testing are given for refractory brick, for refractory materials under load at high temperatures, for softening point of fire-clay brick, and for chemical analysis of refractory materials, including chrome ore and chrome brick. Tentative test methods are also included for the resistance of fire-clay brick to thermal spalling and for determining the particle size of ground refractory materials. It is felt, however, that the methods of sampling, ways of reporting data, and the determination of the precision of the results, have not received as much attention as they deserve. For this reason the interpretation of refractory test data has been included, in which these phases of the testing of refractories are discussed, and methods are given which, if generally followed, should increase the usefulness of data on refractories.

Some of the more important phases of this subject which are discussed include: the importance of sampling and methods of reporting data, analysing data from one sample for inspection purposes, analysing data from one sample for scientific purposes, the interpretation of data from one sample, the interpretation of data from several samples, and the selection of samples.

It will be readily appreciated that the desired effectiveness in the use of refractory tests in the control of manufacture, inspection and utilisation of refractories cannot be attained until test procedures and methods of reporting data are on a sound statistical basis. This manual, which comprises 93 pages, is an important step in this direction. It has been prepared by Committee C-8 on Refractories, the personnel of which comprises qualified representatives from American producing and consuming interests.

Copies can be obtained from A.S.T.M. Headquarters, 1315, Spruce Street, Philadelphia, Pa., U.S.A., at 50 cents each.

Recent Developments in Tools and Equipment

High-speed Roughing Lathes.

THE rapid development of metals and alloys to withstand heavy and continued service has necessitated considerable research in the production of suitable cutting materials to facilitate machining. Remarkable progress has been made in this direction, and the cutting power with modern tools has been improved to a degree formerly considered impracticable. The superior cutting materials now available enable the toughest and hardest of metals and alloys to be cut with comparative ease at greater cutting speeds or with heavier cuts. This development has naturally increased the stresses imposed upon machine tools, and the question of rigidity has become a very vital one. Considerable attention is now being directed to the maintenance of this important feature, and machines are being designed to take full advantage of modern cutting materials. In this direction it is of interest to note that Craven Brothers (Manchester), Ltd., are at present constructing a large range of heavy roughing lathes, for export, which are designed to take full advantage of modern developments in cutting materials and to maintain absolute rigidity in operation, which is so important in practice.

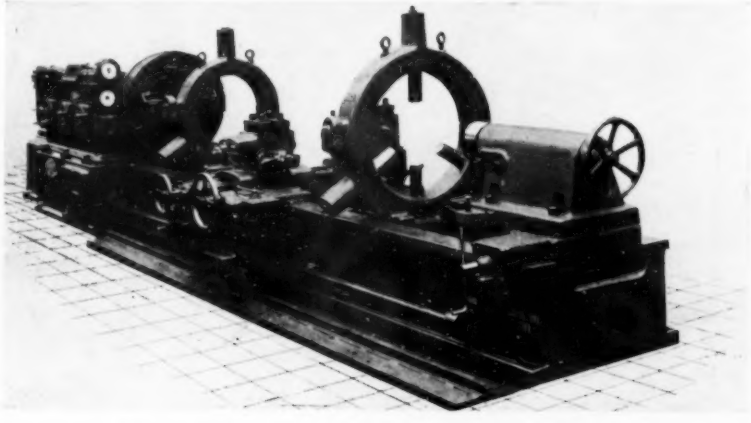


Fig. 1.—20-in. centre lathe arranged for A.C. motor drive.

Built on massive lines, as is shown in the accompanying illustrations, with the object of ensuring stability and the elimination of vibration, when used to remove the maximum amount of metal in the shortest time, these machines have many interesting and valuable features. As will be seen in Fig. 1, which is a 20-in. centre lathe, and representative of the range, the main casting, forming the bed, is of substantial box-type construction. It is designed so that the saddle slides on square-section ways with a narrow front guide. The bed is arranged with chutes to enable the cuttings to fall clear at the back of the machine.

The headstock is constructed on similar substantial lines, and all gears are totally enclosed. The spindle is of large-diameter high-carbon steel revolving in phosphor-bronze bearings, and ball-thrust bearings take the end thrusts from the spindle. The first and final drive wheels in the headstock are cut single helical, and all the gears are heat-treated. They are designed to operate at speeds suitable for using tungsten carbide or high-speed steel tools, and, to ensure stability, all auxiliary shafts are splined and run in roller bearings. The change-gear handles are arranged on the front of the headstock, and a window and lamp are provided for examining the gears when the machine is in operation. As will be noticed, a tachometer and ammeter are provided in a convenient position. A heavy-section, cast-iron faceplate is attached to the spindle; it is fitted with four removable heat-treated steel jaws.

The lathe shown in Fig. 1 is fitted with the standard type of loose headstock. It is designed with a very wide base to eliminate vibration, and is mounted on a sandwich plate, which has a set-over adjustment for parallel or slightly taper turning. This loose headstock is fitted with a large steel revolving centre, amply supported at the front. In the design shown in Fig. 2, which represents a 21-in. centre sliding and surfacing roughing lathe, the loose headstock is fitted with a revolving spindle carrying a four-jaw chuck and adjustable point centre. This special type of loose headstock gives additional support to the work for extra-heavy roughing, and may also be used for rough turning hollow forgings, etc., which could not be held on the ordinary type of centre.

Each of the machines in the foregoing illustrations is fitted with a duplex saddle with front and back rest. It is designed with eight reversible feeds, for both sliding and surfacing, which are provided with interlocks and safety slipping clutches. The saddle is fitted with self-acting surfacing motion, self-acting sliding motion, and hand and quick motion along the bed. All motions are controlled from one position at the front of the machine, whilst the rear slides can also be adjusted from the back. The feed is driven by an enclosed gear in the headstock through a shaft supported on self-acting receding bearings of special design.

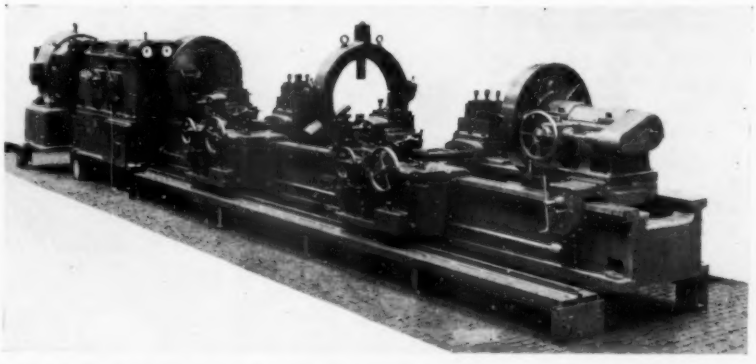


Fig. 2.—21-in. centre sliding and surfacing roughing lathe, arranged for D.C. motor drive.

The drive is effected by means of a variable-speed electric motor through four changes of gearing in the headstock. This, with the aid of the shunt regulator, gives approximately 80 changes of feed to the spindle. Power traverse along the bed is arranged on the loose headstock,

this being done by attaching it to the saddle by means of an easily withdrawn pin.

These machines are controlled throughout by push buttons mounted in convenient positions both on the saddle and the headstock, and safety interlocking devices are provided on each motion so that no conflicting gears can be engaged. The example shown in Fig. 1 is arranged for drive by d.c. motor, while that in Fig. 2 is arranged for a.c. motor drive; either drive can thus be arranged according to requirements. Special attention has been directed to lubrication. This is effected on the headstocks by mechanical means, and on the saddles, loose headstocks, etc., by means of "one-shot" pressure pumps. A cascade oiling system supplies oil to the gear teeth.

The main dimensions of the lathe shown in Fig. 1 are as follows:—

Height of centres, 20 in.
Length of bed, 24 ft.
Will admit 13 ft. 6 in. between centres
Will swing 31 in. over saddles.
Diameter of faceplate, 40 in.
Spindle speeds, 2 to 137 r.p.m.
Eight sliding and eight surfacing speeds.
Main driving motor, 35 h.p.
Approximate weight, less motors, 17½ tons.

One of these roughing lathes on test when using "Widia" cutting tools is shown in Fig. 3. This is a 26-in. lathe, but in general detail is similar to the lathe shown in Fig. 1. It is fitted with two single rest saddles and roller-bearing

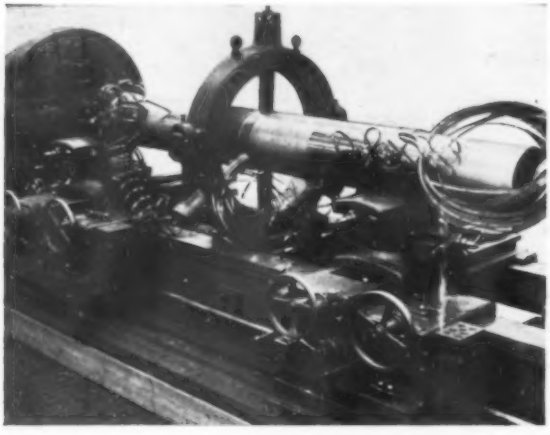


Fig. 3.—High-speed cutting test on a 26-in. lathe, similar in detail to the other lathe illustrated, and fitted with two single rest saddles and roller bearing revolving point centre loose headstock.

revolving point centre-loose headstocks. The lathe shown in Fig. 3 is representative of the type Craven Brothers are producing, and the test in question was carried out on a billet of 45-ton tensile steel, using two tools of Widia metal cutting at the same time, each having a ½-in. depth of cut and $\frac{1}{32}$-in. feed, the speed of cutting being 72 revs., or at the rate of 285 ft. per min.

A high-speed cutting test on a 20-in. centre lathe, on a similar material and using two tools, each tool taking a cut of a ¼ in. with a feed of $\frac{1}{32}$ in., gave a cutting speed of 62 revs., or at the rate of 205 ft. per min.

In each test to which the machines were submitted they withstood the high stresses imposed upon them without any signs of vibration. The manufacturers have always made a feature of sturdiness in construction, but owing to the increasing demands for more power they have built these machines on more massive lines, and in their present form they provide an excellent example of the experience of the machine-tool designer and illustrate the strides made in the progress of rigid machines to facilitate the use of modern cutting materials which ensure a high output with a resultant low cost of production.

LABORATORY AIDS FOR THE PRACTICAL SPECTROSCOPIST.

TWO new laboratory aids for the practical spectroscopist now available from Adam Hilger, Ltd., 98, King's Road, Camden Road, London, N.W. 1, are the "Specpure" substances and the Judd Lewis Spectrum Comparator. Both are applicable primarily to the ratio quantitative system of quantitative analysis devised and described* by Dr. S. Judd Lewis.

The "Specpure" substances are salts and solutions of metals, of which over 50 are prepared, of the highest purity spectroscopically controlled. Besides their application to quantitative chemical analysis by the emission spectrum they may serve many purposes in chemical and physical research, their purity approaching in some cases that accepted in modern atomic weight determinations.

In Dr. Judd Lewis's method the proportion of a minute amount of a minor element in a substance is determined spectrographically in terms of ratio to a dominant element in the substance, by comparison of a spectrum of the substance with one of a ratio powder containing the same dominant element (*e.g.* calcium) in association with a small known proportion of the minor element (*e.g.* zinc) to be determined. The proportion of the dominant element in the specimen can, of course, be determined chemically. A number of standardised ratio powders of differing composition suitable for various types of analysis (plant and animal fibres, soil analysis, biological ashes, etc.) are listed, but special ones can be compounded from the "Specpure" solutions to satisfy any routine or individual problems. These standard ratio substances are available in four forms:—

1. Ratio powders in which certain elements are mixed in fixed proportions with the major component.
2. "Specpure" solid salts of the highest purity.
3. Solutions containing precisely 10 grms. of highly pure anhydrous salt (usually chloride) in 100 cc.
4. Ratio solutions (suitable for compounding ratio powders), standardised to contain precisely one gramme of a metallic element (in the form of chloride) in 100 cc. These ratio solutions may be mixed, volumetrically to "synthesise" a given ash or other material.

The Judd Lewis Spectrum Comparator serves for viewing simultaneously in juxtaposition two spectra on separate plates. It is simply and strongly constructed, and its optical system is so arranged that lines in spectra can readily be compared for intensity as well as for position. It is well adapted to the comparison of every type of spectrum and, in particular, to methods of quantitative spectrum analysis. It ensures accurate results, and saves time and personal fatigue.

Wire-drawing Practice.

The production of wire in non-ferrous metals was probably one of the earliest forms of craftsmanship known to man, and of these metals, copper, by reason of the ease with which it could be obtained, refined, and worked, was amongst the first to be employed. In the earliest times wire was apparently made by hammering down slabs of the metal into very thin sheets, and then cutting these sheets into fine strips or threads.

The process of fashioning wire by drawing came into being in the fourteenth century, but its adoption in this country does not seem to have taken place until 1565, when a Saxon, named Christopher Shutz, came to England under the permission of Queen Elizabeth to draw wire through drawing plates. Prior to Elizabethan times wire was manufactured in a most primitive fashion. Men sat in swings opposite each other with a thin plate of brass attached to a girdle fastened round their waists, and then, by stretching their legs against a stump, they shot their bodies from it, closing with the plate again, and so on until it was stretched into wire.

An interesting booklet on wire manufacture, just issued by I.C.I. Metals, Ltd., gives a brief but lucid description of the practice followed for different kinds of non-ferrous wires, and is admirably illustrated with photographs.

* *Chemistry and Industry*, 51, 271–274, 1932.

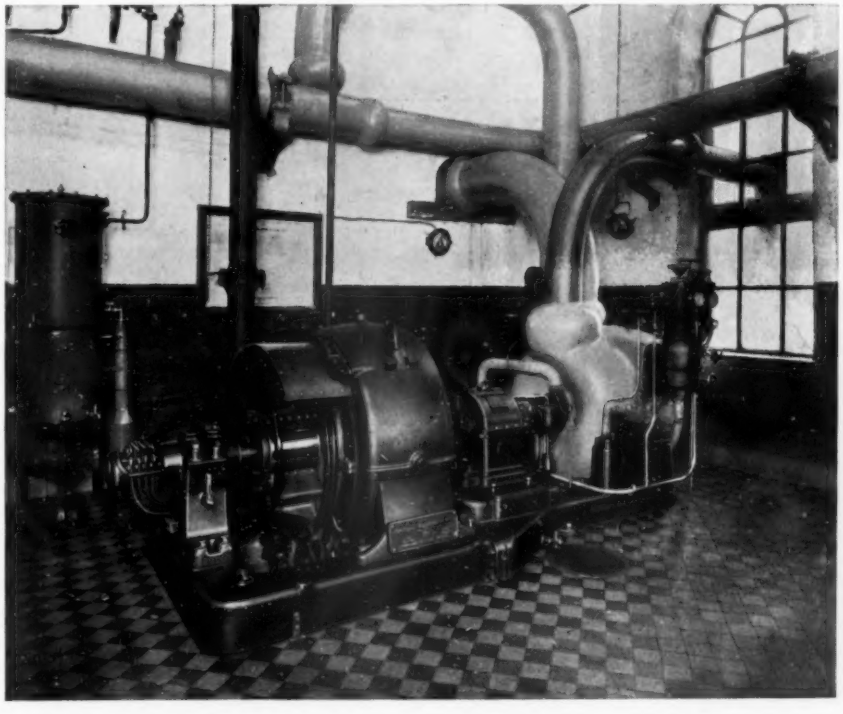
Electrical Power Plant and Blast-Furnace Equipment

Important alterations at the works of the Kettering Iron and Coal Company.

DURING the past few years considerable developments have been in progress at the works of the Kettering Iron and Coal Co., Ltd., Northamptonshire, and important alterations and additions have been made to the auxiliary equipment of the furnaces. A comprehensive scheme of electrification has been carried out, the new plant installed including a 250-kw. geared pass-out d.c. turbo-generator, a 300-kw. reciprocating steam-driven d.c. generator, main switchboard, and a number of electric motors with motor control gear.

The 250-kw. pass-out turbine was designed specially to meet the somewhat unusual conditions of steam supply at this works. There are two banks of boilers supplying steam at 60 lb. per sq. in. and 150 lb. per sq. in. respectively. All boilers are fired with rough-cleaned blast-furnace gas. The 60-lb. per sq. in. steam is used for driving certain reciprocating blowing engines. The turbine takes steam at 150-lb. per sq. in. pressure, and is capable of carrying its full load with all steam passing out at 60 lb. per sq. in., thereby supplementing the steam from the 60-lb. per sq. in. boilers.

The blast-furnace gas supply to the boilers is subject to fluctuations, but arrangements have been made to cope with the most extreme conditions experienced and through making the fullest use of exhaust steam for feed-water heating and treatment, better regulation of the gas supply, and better arrangements for burning it, all coal firing has been cut out, notwithstanding that by means of the special features of the turbine an increased electrical load is carried.



250 k.w. G.E.C.-Fraser and Chalmers pass-out D.C. turbo-generator, 460–230 volts.

The turbine consists of two stages, each being of the velocity type with two rows of moving blades. The first stage is designed for expanding the steam from 150 lb. per sq. in. to 60 lb. per sq. in., and the second from 60 lb. per sq. in. to atmospheric pressure. All steam from the first stage passes out into the 60-lb. per sq. in. steam main. The steam to the second stage is admitted through a reducing valve.

If the steam raised in the high-pressure boilers is insufficient to carry the works load in the first stage of the turbine, then the turbine reducing valve automatically opens and admits 60 lb. per sq. in. steam to the second stage. Also when the pressure in the low-pressure main tends to rise due to a surplus of steam from the 60 lb. per sq. in. boilers, the reducing valve opens to allow steam to pass through the second turbine stage. In this case the high-pressure steam consumption is, of course, correspondingly reduced. The turbine reducing valve is controlled by an Arca regulator, which tends to maintain constant pressure of 60 lb. per sq. in. in the low-pressure steam main. At the same time the reducing valve is also under the control of the speed governor of the turbine. This is necessary because, occasionally, the pressure in both steam mains falls below normal. In this event the Arca regulator closes the reducing valve, but if sufficient steam is not available from the high-pressure boilers to maintain the load on the generator, the reducing valve opens by virtue of the speed governor in spite of the Arca regulator tending to close it. Both the 150-lb. and 60-lb. per sq. in. steam-admission valves of the turbine are connected to the emergency governor.

The extraordinary flexibility of this turbine, which was manufactured at the General Electric Co.'s Fraser and Chalmer's Engineering Works, Erith, Kent, has made it possible to utilise, in a perfectly automatic and economical manner, the fluctuating steam supply from two sets of boilers of different pressure to cover the whole of the power demand of the works.

One of the most interesting sections of these extensions is the electrically driven furnace-barrow hoist, the operating equipment of which comprises a 60-h.p. d.c. Witton motor. This motor is controlled by a 40-kw. Ward-Leonard motor generator set, which is connected to a 460-volt, three-wire d.c. system supplied by the 250-kw. geared turbo-generator, while the 300-kw. set is available as a stand-by.

The Ward-Leonard motor generator is automatically controlled by a master controller and an accelerating drum switch, which is driven from the winder shaft. A brief

description of the method of operation will be of interest. The master controller is operated through rods by a handle situated at the foot of the hoist. For normal working conditions this controller has two main operating positions, namely, "raise" and "lower." On moving the controller over to the "raise" position the exciter contactors for the Ward-Leonard motor generator close, and the generator is excited by a weak field current, thus starting the hoist motor. Immediately the hoist begins to move an accelerating drum switch is operated by the winder shaft and progressively raises the field current in the generator to its full value. In this way the hoist motor is automatically accelerated to full speed. As the hoist reaches the limit of its travel the accelerating drum switch automatically retards the hoist motor by reducing the field current of the Ward-Leonard generator until, finally, a limit switch is tripped which opens the field circuits of the hoist motor and the Ward-Leonard generator, and applies the solenoid brake F to the hoist. For lowering the hoist the same sequence of operations takes place by moving the master controller over to the "lower" position.

The hoist is used for ironstone, limestone, or coke. Each barrow will take 15½ cwt. of ironstone, and as the barrow weight is 7½ cwt., the total load which the hoist raises when dealing with ironstone is 46 cwt. If coke is the load, 27 cwt. is the total weight. It will thus be seen that the load on the motor varies over a relatively wide range, so that it has been necessary to give special attention to the question of decking. For this purpose a set of three contactors G, together with load-discriminating relays H, are provided. Each contactor is energised by the operation of its relay, and short circuits a small resistance in the field circuit of the Ward-Leonard generator, thereby raising the generator voltage and increasing the output of the hoist motor. By this means the generator voltage and the motor output are automatically increased when the hoist handles heavy loads, so that the hoist travels always at its maximum speed and decks accurately. It is of interest to note that satisfactory operation is possible when the barrows are empty, and also that a creeping speed is provided for rope inspection. Precaution against undesired creeping is referred to below.

Protection of the equipment is afforded by an overload relay in the hoist motor circuit, and an emergency switch, which is mounted immediately below the operating handle of the master controller. Operation of either the relay or the master switch trips the main and exciter contactors and automatically applies the solenoid brake.

Although the field circuit of the Ward-Leonard generator is broken when the hoist motor stops, creeping of the hoist might occur owing to the possibility of a small voltage being produced, due to the residual magnetism of the set. In order to obviate any risk of creeping a small, double-pole, double-throw contactor is provided. When de-energised, this contactor connects the field circuit across the generator armature in such a manner as automatically to prevent any building-up of voltage by the generator.

The hoist is automatically stopped should the supply voltage fail during any part of its travel. In this eventuality the accelerating drum switch would not be in the correct position for starting, so that a further resistance is provided in the generator field system. When restarting this resistance can be cut out gradually by slowly operating the master controller, so that the motor can be accelerated to the speed corresponding to the position of the accelerating drum switch, after which the drum switch automatically takes over the control of the hoist. Under normal service conditions this resistance is completely short circuited by moving the master controller to either of the main running positions. A system of electrical interlocking is arranged between the upper and lower stages of the hoist.

Lower end of electrically-driven hoist at the works of the Kettering Iron and Coal Co., Ltd.

Instruments are provided to indicate the exciter voltage, the current taken by the hoist motor and the line current, and are mounted in convenient positions in the motor-room.

Among the many advantages of an electrically driven hoist of this type may be mentioned ease of control so that unskilled labour can be used, rapid yet smooth acceleration, even retardation, and automatic and accurate decking. In this installation the operator simply starts the cage, after which the acceleration, retardation, and stopping are entirely automatic.

The scheme of electrification has lead to important economies, and plant formerly steam driven is now electrically driven. The principal motor drives include two slag-breaking plants, tarmacadam plant, workshops, service pumps, boiler-feed pumps, etc., which, together with the electrical equipment for the hoist, the d.c. generators, switchgear, etc., have been designed and manufactured at the Witton Engineering Works of the General Electric Co., Ltd.

We are indebted to Mr. G. H. Johnson, A.M.I.Mech.E., managing director of the Kettering Iron and Coal Co., Ltd., for permission to publish the information and illustrations contained in this article.

Edward G. Herbert, Ltd., Manchester, has entered into an agreement with the Tinius Olsen Testing Machine Co., of Philadelphia, Pa., U.S.A., to manufacture under licence at Levenshulme the range of Olsen-Lundgren static-dynamic balancing machines for balancing crankshafts, fly-wheels, armatures, rotors, etc. The firm has acted as sole agents in Great Britain and Ireland for Messrs. Olsen for the last 25 years. Henceforward, every component of the Olsen-Lundgren machines manufactured here will be entirely British.

Business Notes and News

South Wales Iron Ore.

Request for Quota Scheme.

The South Wales Miners' Federation are stressing the need for a certain quota of home-produced ore to be used by British consumers of iron ore. Approximately two-thirds of the ore used in this country is home-produced, but in South Wales only about 15% was consumed in the most favourable year, and it is now considerably less. Yet there are millions of tons of unworked iron ore in South Wales. The deposits extend the whole distance under the coalfield, and are found lying under the millstone grit. There are valuable outcrops to the north and south of the coalfield.

With all this valuable ore lying close at hand South Wales iron and steel manufacturers consume ore imported from Spain and North Africa. Last year over 500,000 tons of foreign ore were imported into South Wales, and only 16,000 tons of the Welsh ore used in the steel works.

This Welsh ore is claimed to contain 52% of iron, and in comparison with imported ore, which averages about 50% of iron, it should be possible to compete successfully in price. There is no doubt that South Wales could profitably make use of her resources to a greater extent, particularly as it would assist in overcoming her serious unemployment problem.

Rationalisation of Shipping.

In a statement issued by the Shipping Policy Committee of the Chamber of Shipping it is apparent that a laying-up scheme for the reduction of tonnage, submitted to owners throughout the country, does not command a sufficient measure of support to enable it to be put into operation. The Committee felt that no stone should be left unturned to achieve rationalisation of the industry, and in order to counteract the disastrous effects of the crisis, a proposal was considered and, it is understood, will be submitted to owners for modifying the laying-up scheme by the addition of a contribution from owners, to be returned in the form of a deferred rebate in proof of laying-up of vessels for an agreed period.

In addition the Committee are considering a number of proposals for scrapping of tonnage, and it is hoped to submit a practical scheme on these lines for consideration by owners generally. The serious position which has arisen from the continued growth of foreign subsidies to shipping was also considered, and it is understood that a possibility of counter-vailing measures in the event of subsidies continuing is under consideration.

The Woodhall-Duckham Companies.

At a meeting of the Board of the Woodhall-Duckham Vertical Retort and Oven Construction Co. (1920), Ltd., held on Friday, September 23, 1932, Mr. F. B. Richards was appointed chairman of that company. The board also appointed a Committee of Management, consisting of the chairman (Mr. F. B. Richards), the managaing director (Mr. G. J. Jackson), who will continue to be responsible for the Company's constructional work, and the technical director (Dr. E. W. Smith), who will have charge of the design, development, and operation sides of the Company's business.

Mr. Richards and Mr. Jackson have for some years been the managing directors of the Company, and have been associated from the earliest days with the late Sir Arthur Duckham in the development of the Woodall-Duckham continuous vertical retort, and in the building up of the Woodhall-Duckham Companies. Dr. E. W. Smith has held the position of technical director to the Woodhall-Duckham Companies since 1920. Mr. F. B. Richards was also elected chairman of Woodhall-Duckham (1920), Ltd., at a meeting of the board of that Company held on the same day.

The President-elect of the Iron and Steel Institute.

The Council of the Iron and Steel Institute has selected Mr. W. R. Lysaght to succeed Col. Sir Charles Wright, Bt., as president at the termination of his year of office at the next annual meeting. In making this announcement at the recents autumn meeting, Sir Charles stated that Mr. Lysaght was connected with many of the great trades of this country, and no one had a greater or more practical knowledge of the steel industry. The office of president would be enriched by his appointment.

Monel-Weir Merger.

We are informed that the organisation of Monel-Weir, Ltd., has been merged with that of Henry Wiggin and Co., Ltd., and the combined businesses will be conducted by, and in the name of, the latter Company from their head offices at Thames House, Millbank, London, S.W. 1. Mr. John Ireland, who was managing director of Monel-Weir, Ltd., together with his principal assistants, is now located in London, and will be responsible for the sales of Monel metal, thus preserving the continuity of the business.

For some little time past Monel metal has been produced at the Birmingham works of Henry Wiggin and Co., Ltd., where up-to-date plant has been installed for the purpose of producing numerous types of nickel and nickel-alloy products. Monel-metal tubes, turbine blading, castings, etc., will continue to be manufactured as hitherto. The joint experience of the two Companies should help to promote the rapid development of the use of nickel and its alloys in industry generally, and there can be no doubt that this amalgamation will prove to be advantageous to all users. Certainly we are confident that Henry Wiggin and Co., Ltd., will spare no effort to give prompt and efficient service, as has been the endeavour of the old Company.

In addition to the head offices in London, Henry Wiggin and Co., Ltd., have a number of branch offices, and to facilitate correspondence in the provinces we append the addresses of these branch offices. Birmingham: Wiggin Street, Birmingham. Sheffield: Arundel Street, Sheffield. Manchester: 22, St. Mary's Gate, Manchester. Glasgow: 108, West Regent Street, Glasgow.

The Thames Cable Towers.

Those members of the Iron and Steel Institute and the Institute of Metals who joined the river excursion to the Ford Works at Dagenham, on the occasion of the recent London meeting, would notice the two large towers which have been erected on the Thames estuary for the transmission of electrical energy over the river. The north main tower is at Horseshoe Corner, near Dagenham Dock, and the south tower is on ground owned by Woolwich Arsenal. There are two anchor towers, and the distance between all the towers will be over 6,000 ft., while the height of the main towers is 487 ft. They are designed to carry two circuits, each of 50,000 kw., at a transmission voltage of 132,000 volts.

The towers have been designed to withstand a maximum working tension of 25,650 lb., while the conductors have an ultimate strength of 57,600 lb.; the total weight of the latter being 44,340 lb. The weight of each main tower is approximately 280 tons; the width at the base being about 120 ft. they are constructed of rolled-steel sections.

The conductors—six in number—are composed of special copper-alloy wires, seven centre wires of cadmium copper, surrounded by 84 wires of phosphor bronze, the diameter of the cables being nine-tenths of an inch.

Each crossing tower will be lighted by means of illuminated crosses located at points one-third and two-thirds of the height of the towers. There will be two crosses on the up-river, down-river, and land-side faces of each tower, the side facing the river being unlighted. The apex of the towers will also be equipped with lights.

Training in Electric Welding.

Three separate courses of instruction suited to the welding operator, the technical foreman or supervisor, and the designer are provided by Murex Welding Processes in their welding school. Both the supervisors' and the designers' courses are, to a large extent, theoretical, and it is expected that prospective students will first take the operators' course so as to obtain a knowledge of the essential details of the art.

The courses are intensive in character, and are intended to cover their separate fields in the minimum time. The operators' course covers a period of instruction of 14 days, while an addition of seven days is necessary for both the supervisor and designer course. These times may, of course, be extended, or changed to meet the special need of the trainee. Information regarding these courses may be obtained from Murex Welding Processes Ltd., Ferry Lane Works, Forest Road, London, E. 17.

The annual report on the quarrying and metalliferous mining industries for 1931 states that over 73,000 persons were employed in the quarrying industry and nearly 10,000 in metalliferous mines. The value of the production was £16,500,000.

Some Recent Inventions.

Electric Induction Furnaces.

In the use of coreless induction furnaces it is sometimes found that the stirring produced is excessive, while at other times it is necessary to increase this effect at certain stages of the operation without appreciably changing the power input. It has been recognised that the stirring effect may be altered by mechanically lifting or lowering the inductor coil with respect to the charge, or by providing the induction coil with a series of tappings at variable heights, so that the current can be made to traverse one portion only of the coil between any selected tappings. Until recently these known methods of controlling the stirring have had only a limited application, either on account of the complicated construction required to lift or lower the coil, or due to the small portion of the inductor coil that can be used at any given time, and the excessive heating of the idle coil portions.

A new method of controlling the stirring action has been developed in which the inductor coil surrounding the crucible or hearth consists of two portions connected in parallel to the supply, and wound so that current traversing these

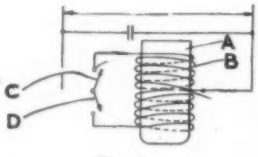


Fig. 1.

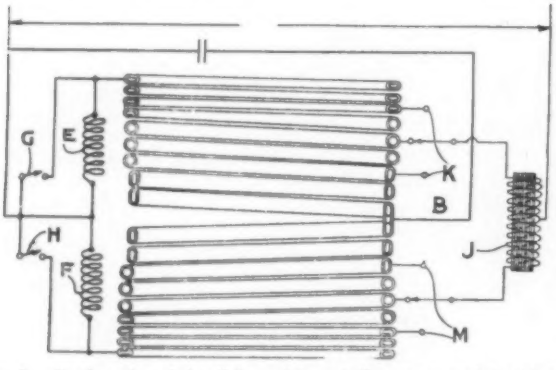


Fig. 2.—*Section of graded coil formed from hollow water-cooled tubings*

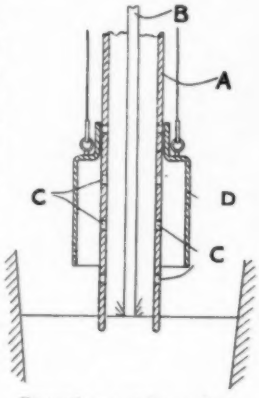
portions in parallel produces a magnetic field in the same direction in each portion. Switching means are provided, so that both parts can be made operative as required. Switches may be provided by which either or both coils can be connected to the source of supply, or impedances inserted in either part of the coil can be short-circuited by switches, in order that the current, in a portion in which the impedance is not short-circuited, is practically inoperative. Making the inductances capable of adjustment will enable the strength of the current in either circuit to be varied as required, and will allow the stirring action to be concentrated at any time of the charge during the various stages of the working operations. Fig. 1 shows one of a series of diagrams illustrating various circuit connections in which the crucible A is surrounded oy the inductor coil B, which is composed of two parts connected in parallel, and wound so that the fields produced are in the same direction, the switches C and D controlling either part.

Various modifications are illustrated and described, and Fig. 2 shows a section of a graded coil formed of hollow, water-cooled tubing, the connections being shown diagrammatically and the crucible and charge excluded. In this case fixed or variable inductances E and F, provided with or without iron cores, may be arranged in series with the two parts of the coil, switches G and H being provided for short-circuiting the inductances. The coil may be provided with tappings, and may be fed through a choke J. The tappings K, M may be connected together at the centre of the coil B. The choke-coil in this instance consists of two windings in the same direction from end to end of the core. The induction coil may have varying ampere turns per unit length, and may be tubular. In a further modification, the induction coil consists of two units, each comprising two portions oppositely wound, and an additional inductance and short-circuiting switch is provided in connection with each unit.

371,553. Electric Furnace Co., Ltd., 17, Victoria Street, London, S.W. 1 (assignees of E. F. Northrup, Ajax Park, Trenton, New Jersey, U.S.A.), patentee; Abel and Imray, Southampton Buildings, London W.C. 2, agents. Accepted April 28, 1932.

Protecting Metals against Oxidation when Casting.

When pouring an ingot the metal flowing from the ladle delivers air and oxides to the metal in the mould and also tends to draw in and submerge scum. Both these actions result in the production of inferior materials. To eliminate these disadvantages, it has been suggested to cast ingots in vacuo or in a neutral or reducing atmosphere. A method recently devised provides improved means for ensuring that the stream of metal issuing from the ladle when pouring is surrounded by the desired atmosphere, that the surface of the metal in the mould is protected against oxidation, and that surface scum is not dranw down into the casting. In this method the orifice or spout of the ladle is fitted with a sleeve or extension through which the stream of metal passes to the mould, and into which a reducing or neutral gas is supplied, so as to surround the metal passing through the sleeve.



Protecting metals against oxidation.

The method is particularly suitable for application to bottom pouring ladles by arranging a vertical sleeve. One application of the method is shown in Fig. 1, in which A represents the sleeve surrounding the stream of metal B. The sleeve may be telescopic, and be adjusted so that its end is just above the rising metal, or it may have a lower thin-walled section which is melted by the rising metal. In this case the sleeve may be made of or coated with slag-forming material, or be made of the same metal as that being case, or of a metal which it is desired to add so as to form an alloy or act as a deoxidiser, etc. Holes C for the escape of the gas or an adjustable muff D, or both may be provided. If a muff only is used it is also supplied with gas. The sleeve may be vertically corrugated and strengthened internally or externally or both by rings or helices attached by spot welding or otherwise. The gas escaping from the sleeve and muff protect the surface of the metal in the mould from oxidation.

371,880. R. W. Bailey, 20, Grange Avenue, Hale, Cheshire, and Associated Electrical Industries, Ltd., Crown House, Aldwych, London, patentees; A. S. Cachemaille, 2, Norfolk Street, Strand, W.C., agent. Accepted April 26, 1932.

New Master Cutler of Sheffield.

Lieut.-Col. A. N. Lee, a director of the cutlery firm of Messrs. Walker and Hall, was recently elected Master Cutler of Sheffield. The 300-years-old ceremony took place with all the usual accompaniments, members of the Cutlers' Company walking in procession through the centre of the city headed by a liveried beadle bearing the Mace. Col. Lee, in a speech, strongly criticised the present municipal and national expenditure. The country, he said, had for years been living beyond its means.

ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD.
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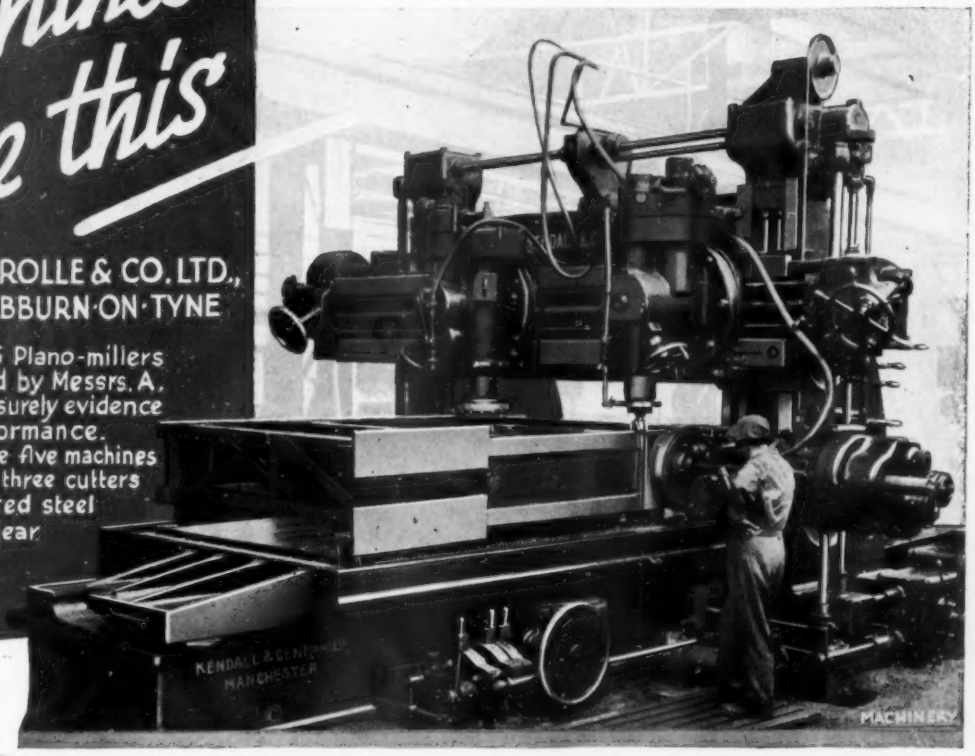
AT MESSRS. REYROLLE & CO. LTD., HEBBURN-ON-TYNE

That five large K&G Plano-millers have been installed by Messrs. A. Reyrolle & Co. Ltd. is surely evidence of economical performance. The largest of these five machines is shown here, with three cutters at work on fabricated steel frames for switchgear.



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with one, two, three or four spindles.

Screwing Machines for bolts and nuts, and for tubes.

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Milling machines have long been a K&G speciality and in the range of many types and sizes there are machines to help reduce your own production costs.

May we send you full particulars ?

KENDALL & GENT (1920) LTD.
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MANCHESTER.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£95	0	0

ANTIMONY.

English	£35 0 0 to £42	10	0
Chinese	25	0	0
Crude	16	0	0

BRASS.

Solid Drawn Tubes	lb.	9½d.
Brazed Tubes	lb.	11½d.
Rods Drawn	,,	8½d.
Wire	,,	7⅝d.
*Extruded Brass Bars	,,	4d.

COPPER.

Standard Cash	£32	2	6
Electrolytic	36	10	0
Best Selected	34	5	0
Tough	33	15	0
Sheets	65	0	0
Wire Bars	37	0	0
Ingot Bars	37	0	0
Solid Drawn Tubes	lb.	10½d.	
Brazed Tubes	,,	10½d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	2	0
‡Ferro Tungsten	,,	0	1	9
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2-4% Carbon, scale 12/- per unit	ton	35	15	0
NOMINAL: 4-6% Carbon, scale 8/- per unit	,,	26	0	0
NOMINAL: 6-8% Carbon, scale 8/- per unit	,,	24	8	0
NOMINAL: 8-10% Carbon, scale 8/- per unit	,,	23	10	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/6 per unit	,,	36	15	0
Guar. max. 1% Carbon, scale 14/ per unit	,,	40	15	0
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	44	10	0
‡Manganese Metal 96-98% Mn.	lb.	0	1	4
‡Metallic Chromium	,,	0	2	8
§Ferro-Vanadium 25-50%	,,	0	12	8
§Spiegel, 18-20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	5	17	6
20/30% basis 25%, scale 3/6 per unit	,,	8	10	0
45/50% basis 45%, scale 5/- per unit	,,	13	15	0
70/80% basis 75%, scale 7/- per unit	,,	19	0	0
90/95% basis 90%, scale 10/- per unit	,,	30	0	0
§Silico Manganese 65/75% Mn., basis 65% Mn.	,,	14	5	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	6
Ferro Phosphorus, 20-25%	ton	21	17	6

FUELS.

Foundry Coke—						
S. Wales	£1	0	0 to	1	2	0
Sheffield Export	—			—		
Durham	1	1	0 to	1	4	0
Furnace Coke—						
Sheffield	—			—		
S. Wales	0	16	0 to	0	16	6
Durham	—			0	12	0

GUN METAL.

*Admiralty Gunmetal Ingots (88:10:2)	£49	0	0
*Commercial Ingots	39	10	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9½
*Cored Bars	,,	0	0	11½

LEAD.

Soft Foreign	£11	18	9
English	13	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	11	0	0
Best Bars	10	10	0
Common Bars	10	0	0
Lancashire—			
Crown Bars	9	15	0
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars £9 15 0 to	10	0	0
Marked Bars	12	0	0
Unmarked Bars	—		
Nut and Bolt Bars £8 7 6 to	8	12	6
Gas Strip	10	12	6
S. Yorks.—			
Best Bars	10	10	0
Hoops. Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	,,	11d.
†Strip	,,	10½d.
†Sheet to 10 W.G.	,,	11d.
†Wire	,,	11¾d.
†Rods	,,	11d.
†Tubes	,,	1/4
†Castings	,,	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	7	6
Foundry No. 1	3	10	0
,, No. 3	3	7	6
N.E. Coast—			
Hematite No. 1	3	0	0
Foundry No. 1	3	1	0
,, No. 3	2	18	6
,, No. 4	2	17	6
Cleveland—			
Foundry No. 3	2	18	6
,, No. 4	2	17	6
Silicon Iron	3	1	0
Forge No. 4	2	17	0
Midlands—			
N. Staffs Forge No. 4	3	1	0
,, Foundry No. 3	3	6	0
Northants—			
Forge No. 4	2	17	6
Foundry No. 3	3	2	6
Derbyshire Forge	3	1	0
,, Foundry No. 3	3	6	0
West Coast Hematite	3	6	0
East ,, ,, No. 1	3	0	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron ..... 93 KRONOR.

Billets	£12	13	6 to	£16	0	0
Wire Rods	£14	12	0 ,,	£17	12	6
Rolled Bars (dead soft)	£10	4	0 ,,	£11	11	0
Rolled Charcoal Iron Bars	—			£16	0	0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£26	0	0
,, Brazery	23	0	0
,, Wire	—		
Brass	19	0	0
Gun Metal	22	0	0
Zinc	8	10	0
Aluminium Cuttings	72	0	0
Lead	11	0	0
Heavy Steel—			
S. Wales	1	18	6
Scotland	1	12	6
Cleveland	1	15	0
Cast Iron—			
Midlands	1	15	0
S. Wales	1	19	0
Cleveland	1	16	0
Steel Turnings—			
Cleveland	1	7	6
Midlands	0	19	0
Cast Iron Borings—			
Cleveland	1	2	6
Scotland	1	10	0

SPELTER.

G.O.B. Official		—	
Hard	£12	15	0
English	15	17	6
India	14	5	0
Re-melted	15	0	0

STEEL.

Ship, Bridge, and Tank Plates—			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
,, ,, (Marine) ,,	—		
,, ,, (Land), N.E. Coast	10	0	0
,, ,, (Marine) ,,	10	10	0
Angles, Scotland	8	7	6
,, North-East Coast	8	7	6
,, Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester—			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	lb.	2/9
Extras		
Round and Squares, ⅛ in. to ½ in.	,,	3d.
Under ¼ in. to ⅛ in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅛ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£151	10	0
English	153	5	0
Australian	155	7	6
Eastern	155	15	0
Tin Plates I.C. 20 × 14 box	0	16	0
Block Tin (Cash)	151	5	0

ZINC.

English Sheets	£24	10	0
Rods	27	0	0
Battery Plates		—	

* McKechnie Brothers, Ltd., quoted Oct. 11. † C. Clifford & Son, Ltd., quoted Oct. 11. ‡ Murex Limited, quoted Oct. 11.
Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.
§ Prices quoted Oct. 11, ex warehouse.